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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Full Page Advt., page 82, Sept. 17.

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Walter Somers & Co., Ltd., HALESOWEN. 7116

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See Advertisement page 100. 2402

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See Full Page Advertisement, Sept. 17.

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Engines and Dynamos could be sold separately.
Also TWO 500 Kw. PARSONS TURBINES, 220-250 Volts, D.C. (in series 440-500 volts), complete with Spare Armature and Condenser.
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See half-page Advertisement, page 90, Oct. 1.

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MECHANICAL & ELECTRICAL ENGINEERING
Will COMMENCE on
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JOHN J. JACKSON, B.A.,
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J 883

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THE HARROW ELECTRIC LIGHT & POWER CO., Ltd., invite

Tenders for the Purchase and

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Three 60 Kw. Willans-Crompton GENERATING SETS. 460 volts, steam pressure 160 lbs., including one Spare Armature.
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Four Babcock WATER TUBE BOILERS, 180 lbs. working pressure; two 30 tubes arranged for hand firing, two 31 tubes fitted with chain grate stokers, 5 H.P., 440 volts, Motor and Starter.
One Green's ECONOMISER, 72 tubes, complete with 2 H.P. 440 volts Motor and Starter.
One Induced Draft SIROCCO FAN, direct coupled to E.C.C. 9 H.P., 440 volts Motor.
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One Thomas Parker Double Battery BALANCER BOOSTER SET. Boosters 60 amps., 105 volts. Balancer 30 amps., 220 volts, including one Spare Armature.
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Further particulars and permit to inspect may be obtained from the undersigned or from the Consulting Engineers to the Company, Messrs. May & Hawes, 26, Victoria Street, Westminster.
W. H. BISHOP,
Secretary and Manager.
College Road,
Harrow. J 904

Tenders are Invited for

SECOND-HAND TRANSFORMERS in good working condition as follows:—
Six 5 K.W. and six 10 K.W. capacity single phase oil insulated transformers suitable for outdoor pole mounting. Primary voltage 2,000 secondary 105 and 210 for periodicity of 100. Transformers should be provided with earth shield safety device between primary and secondary windings.
Tenders should be addressed to the CHIEF ENGINEER, Crown Agents for the Colonies, 4, Millbank, S.W. 1, and reference W/Malta 4341 quoted. K 93

ABERDEEN CORPORATION WATER WORKS.

EXTENSIONS, 1920.

Contract No. 2—
ADDITIONAL STORAGE RESERVOIR.

The TOWN COUNCIL OF ABERDEEN are prepared to receive

Tenders from Competent

Persons willing to enter into a Contract for the CONSTRUCTION of a STORAGE RESERVOIR and Ancillary Works at Inverc annie, near Banchory Railway Station.
The work comprises about
70,000 cub. yds. Excavation.
18,000 cub. yds. Concrete.
30,000 sq. yds. Asphalting.
The Drawings may be inspected, and Specifications, Schedules of Quantities, and Forms of Tender obtained on and after 15th October, 1920, on application at the Water Engineer's Office, 41½, Union Street, Aberdeen.
For each Specification a deposit of Five pounds sterling in cash will be required, which sum will, after a tender has been accepted, be returned to the Tenderer, provided that he shall have sent in a bona fide tender, based on the Drawings, Specification and Schedule of Quantities provided, with the Schedule of Quantities and other Schedules fully priced out in detail and shall not have withdrawn the same. Provision is made for adjustment of the contract sum to meet alterations in the cost of labour and materials.
The site may be inspected at any time by appointment.
Tenders on the Forms prescribed and enclosed in securely sealed envelopes, endorsed "Tender for Storage Reservoir" and addressed to the undersigned, must be delivered not later than 5th November, 1920.
The Town Council do not bind themselves to accept the lowest or any Tender.
GEORGE MITCHELL, M.I.Mech.E.,
Water Engineer.
Water Engineer's Office,
41½, Union Street, Aberdeen.
1st October, 1920. K 130

TO CONTRACTORS.

BELFAST WATER WORKS.

MOURNE SCHEME.

Contract A.

For the Construction of the
"SILENT VALLEY" STORAGE RESERVOIR, &c.

The Belfast City and District Water Commissioners are prepared to receive

Tenders from Competent

CONTRACTORS for the CONSTRUCTION of the "SILENT VALLEY" STORAGE RESERVOIR, &c., in the MOURNE MOUNTAINS, County Down, having an Earthen Embankment about 1,600 ft. long and 90 ft. high, and a storage capacity of 2,000 million gallons, with an Outlet Tunnel, Waste Channel, and other auxiliary works, also the construction of a temporary Works Railway.
The Contract Drawings and Specification have been prepared by the Commissioners' Chief Engineer, Mr. F. W. M'Cullough, M.Inst.C.E., Water Office, Royal Avenue, Belfast, and may be inspected at his Office on any weekday (except Saturday), between the hours of Ten a.m. and Five p.m.
Duplicate Copies of the Specification and Form of Tender, &c., may be obtained from the undersigned upon payment of the sum of Five Guineas. This sum will only be repaid by the Commissioners after the receipt of a bona fide Tender which has not been withdrawn.
On the Tuesday and Friday of each week, commencing with Tuesday, the 26th inst., an Assistant Engineer will meet intending Contractors at the Engineer's Office, at Ten o'clock forenoon, and accompany them to the site of the proposed Works.
Tenders, sealed and endorsed "Tender for Silent Valley Storage Reservoir, &c.," must be delivered by registered post, and addressed to the undersigned, not later than Three p.m. on Wednesday, 3rd November, 1920.
The Commissioners do not bind themselves to accept the lowest or any Tender, nor will they be responsible for any expenses incurred in making out a Tender.
W. I. QUINN,
Secretary,
Water Office, Royal Avenue,
9th September, 1920. Belfast. J 787

TO CONTRACTORS.

BELFAST WATER WORKS.

MOURNE SCHEME.

Contract A.

For the Construction of the
"SILENT VALLEY" STORAGE RESERVOIR, &c.

SCHEDULE OF QUANTITIES.

A Detailed "Schedule of

QUANTITIES" has been prepared by me for the above Extensive Storage Reservoir and other Works in the Mourne Mountains, County of Down. Contractors wishing to Tender for this work will be supplied with Printed Copies of the "Schedule of Quantities" on application and payment to me of the sum of Three Guineas per Copy, which sum will not be repayable.
ACHESON FERGUSON,
Quantity Surveyor,
Scottish Provident Buildings,
9th September, 1920. Belfast. J 788

Belting (Leather, Cotton, Hair

and Balata) WANTED for export to Bombay. TENDERS to JAMES SMITH, Ltd., 31, Bush Lane, London, E.C. 4. J 909

INDIA OFFICE,
Whitehall, S.W. 1.
7th October, 1920.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL is prepared to receive:—

Tenders from such

Persons as may be willing to SUPPLY BRASS BOILER TUBES, } (1)
STEEL BOILER TUBES, }
TYRES, STEEL, ENGINE, } (2)
LOCOMOTIVES.

The Conditions of Contract may be obtained on application to the Director General of Stores, India Office, Whitehall, S.W. 1, and Tenders are to be delivered at that Office by Two o'clock p.m. on Tuesday, the 26th October, 1920, for No. 1; and on Friday, the 5th November, 1920, for No. 2, after which times respectively no Tender will be received.
G. H. COLLIER,
Director General of Stores.
K 108

BOMBAY, BARODA AND CENTRAL INDIAN RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 22nd October,

Tenders for the Supply of:—

1. PAINTS, &c.
2. WROUGHT IRON OR STEEL PIPING.
3. FILES.

Tenders may be made on forms, copies of which with specification, can be obtained at these offices on payment of 10/- each (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.
S. G. S. YOUNG,
Secretary.
Offices:
White Mansions,
91, York Street,
Westminster, S.W. 1.
4th October, 1920. K 120

MANCHESTER CORPORATION GAS DEPARTMENT.

LOCO. FOR DISPOSAL.

The Gas Committee are prepared to receive

Tenders for the Purchase and

REMOVAL of:—
One SADDLE TANK LOCOMOTIVE, Four Wheels coupled, Wheel Base 6 ft. 3 in., Standard Gauge.
Cylinders 13 in. diameter by 18 in. Stroke.
Boiler fitted with 120 Brass Tubes and Copper Firebox, Approximate weight unloaded 18 tons.
(Makers, Beyer, Peacock & Co., Ltd., Manchester).
The above can be inspected at the Bradford Road Gas Works, on application to the Manager.
Form of Tender can be obtained on application to Mr. Godfrey Wm. Kaye, Secretary, Gas Department, Town Hall, Manchester.
Sealed Tenders, addressed to the Chairman of the Gas Committee and endorsed "Tender for Purchase of Locomotive," and delivered at the Gas Offices, Town Hall, Manchester.
By Order,
THOMAS HUDSON, Town Clerk.
Town Hall, Manchester,
September 24th, 1920. K 8

METROPOLITAN WATER BOARD.

TENDERS FOR THE CONSTRUCTION OF COVERED SERVICE RESERVOIR AT BROMLEY, KENT.

The Metropolitan Water Board invite

Tenders for the Construction

of a COVERED SERVICE RESERVOIR of a capacity of about five million gallons at Bromley situate in the Parish of Bromley, in the County of Kent.
Drawings, Conditions of Contract, and Specification, may be inspected at the Offices of the Board (Chief Engineer's Department), 173, Rosebery Avenue, Clerkenwell, E.C., on and after Monday, 11th October, 1920.
Forms of Tender, Conditions of Contract, Specification, Bills of Quantities, and copies of the Contract Drawings, together with a spare copy of the Bills of Quantities, may be obtained from the Chief Engineer on production of an official receipt for the sum of £10, which sum must be deposited with the Accountant to the Board at 173, Rosebery Avenue, Clerkenwell E.C. 1. and will be returned on receipt of a bona fide Tender together with all the above named documents, with the exception of the spare copy of the Bills of Quantities which may be retained by the tenderer. Such payments and applications must be made between the hours of Ten a.m. and Four p.m., except Thursdays and Saturdays.
Tenders enclosed in sealed envelopes addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, Clerkenwell, E.C. 1," and endorsed "Tender for Reservoir at Bromley," must be delivered at the Offices of the Board not later than Ten a.m. on Monday, 1st November, 1920.
The Board do not bind themselves to accept the lowest or any Tender.
A. B. PILLING,
Clerk of the Board.
Offices of Board,
173, Rosebery Avenue,
Clerkenwell, E.C. 1.
30th September, 1920. K 155

APPOINTMENTS OPEN.

CITY AND GUILDS (ENGINEERING) COLLEGE.

DEPARTMENT OF MECHANICS AND MATHEMATICS.

Two Demonstrators Required,

the work consists of teaching and class work. Total stipend £270 a year. Applications and statement of qualifications to be sent to Professor FORSYTH, F.R.S., Imperial College of Science and Technology, South Kensington, S.W., not later than 18th October, 1920. K 143

Wanted, Well-qualified

WHOLE TIME TEACHER of Metal Work and Mechanical Engineering Subjects. Minimum salary £250 per annum and bonus. For full particulars and application form, send stamped addressed envelope to J. HAGUES, Principal, Technical College, Doncaster. K 60

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE.

The Governors require the

Services of Engineering

LECTURERS for day and evening classes:—
Lecturer in Mechanical Engineering.
Lecturer in Mechanical and Electrical Engineering.
Salary Scales:—
Grade I. £160—£10—£380.
Grade II. £360—£10—£390—£15—£500.
The commencing salary in each case will be determined by previous experience in teaching or in industry, for which full allowance will be made in accordance with scale.
Particulars may be had from the PRINCIPAL, to whom applications should be forwarded as early as possible. K 65

SUNDERLAND EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE.
Principal: V. A. Mundella, M.A., B.Sc.

PHYSICS AND ELECTRICAL ENGINEERING DEPARTMENT.

Applications are Invited for

the POSITION of ASSISTANT in this Department.
Applicants must have had a University or Technical Institution training, and be qualified to take classes in Physics for Engineers and in the less advanced stages of Electrical Engineering.
Full particulars and forms of application, together with "Scale of Salaries and Regulations Governing Appointment," may be obtained on application to the Principal of the Technical College.
Commencing salary £250 to £370, according to experience and qualifications, with annual increments of £15 to £400, then by £10 per annum to £450.
Applications, with three references or testimonials, should reach the undersigned as soon as possible, and not later than Tuesday, October 19th.
HERBERT REED,
Chief Education Officer.
Education Offices,
16, John Street,
Sunderland. K 96

SUNDERLAND EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE.
Principal: V. A. Mundella, M.A., B.Sc.

MECHANICAL ENGINEERING DEPARTMENT.

Applications are Invited for

the POSITION of ASSISTANT in this Department.
Applicants must have had a University or Technical Institution training, combined with good workshop experience.
Full particulars and forms of application, together with "Scale of Salaries and Regulations Governing Appointment," may be obtained on application to the Principal of the Technical College.
Commencing salary £250 to £370, according to experience and qualifications, with annual increments of £15 to £400, then by £10 per annum to £450.
Applications, with three references or testimonials, should reach the undersigned as soon as possible, and not later than Tuesday, October 19th.
HERBERT REED,
Chief Education Officer.
Education Offices,
16, John Street,
Sunderland. K 97

LONDON COUNTY COUNCIL.

There is a Vacancy for a

WHOLE-TIME MAINTENANCE MECHANIC at the L.C.C. School of Engineering and Navigation, High Street, Poplar, at the current trade union rate of pay, at present £4 13s. 11d. a week of 47 hours. The selected candidate will be required to keep tools and machinery in repair, and should be an experienced fitter and machine man. No teaching work will be required to be undertaken.
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K 148

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THE DESIGN OF AEROPLANE CONTROL SURFACES WITH SPECIAL REFERENCES TO WING AILERONS.

By H. B. Irving, B.Sc., A.F.R.Ae.S., of the National Physical Laboratory.

It is an undoubted fact that aeroplanes of the present day exhibit great differences in controllability, which have not come about entirely as a result of differences in the intentions of designers, but which are, to a considerable extent, accidental. There appear to be two main reasons for this state of affairs. Firstly, very few data on the aerodynamic properties of control surfaces have been available; and, secondly, there are no established criteria of controllability according to which it may be laid down exactly how controllable any given machine should be.

It is the object of the present paper to present information with respect to the aerodynamic properties of control surfaces and to give some analysis of the factors which govern that elusive property of an aeroplane, termed controllability. Attention will be directed, first to controllability since the rational design of control surfaces is based upon a clear understanding of what is implied by this term and since a realisation of the true significance of the information presented later depends also upon the understanding of the meaning of controllability.

Suppose that the pilot of an aeroplane exerts a definite force in application of one or other of the controls. The result will be a moment, exerted on the appropriate control member, whose magnitude depends upon the "gearing" between control lever and control member. The control member turns through an angle until the moment of the wind forces acting on it becomes equal and opposite to the applied moment. The angle turned through depends upon such characteristics of the control members as their size, shape, location, &c., and also on whether they are balanced or partially balanced. When they have turned through an angle they cause a disturbing moment to be exerted upon the aeroplane: Here, again, the size, shape, and disposition of the control members enter in. Finally, the machine responds to the moment exerted upon it and performs an evolution at a rate depending upon its various aerodynamic characteristics, including stability and moment of inertia.

Now controllability, as it is generally understood, depends upon the relation between the pilot's effort and the response of the machine to that effort; the greater the effort required to perform a given evolution the less the controllability and *vice versa*. The term controllability however, is sometimes used in other senses, as, for instance, when the smallest time in which an aeroplane will bank 45 deg. when the ailerons are put hard over is referred to as giving some measure of its controllability in roll. Controllability in such a sense as this is, however, in reality maximum controllability, and it would appear legitimate to measure it as such without any reference to the pilot's effort; for maximum controllability is usually only made use of on special occasions, to execute special manœuvres, and, generally, the effort required is of comparatively short duration. The effort required for maximum control may be of any magnitude up to the maximum which the pilot can exert; the angle through which the control surfaces turn for maximum control may be limited either by the strength of the pilot or by the range of movement which is mechanically possible.

When controllability is taken to depend on the relation between pilot's effort and aeroplane's response, a comparison of the controllabilities of machines cannot properly be made unless the maximum controllability is the same in each case.

At this stage, to prevent confusion of thought, it will be well to define the meanings of the various terms used in this paper concerning controllability.

Four terms will be used:—

(*a*) Control, or efficiency of control.
(*b*) Maximum control.
(*c*) Controllability.
(*d*) Maximum controllability.

Control or efficiency of control is the ratio of the moment exerted on the aeroplane to the effort required on the part of the pilot to produce that moment.

Maximum control is the maximum moment which can be exerted on the aeroplane by movement of the control surfaces.

Controllability is the ratio of the rate at which an aeroplane performs a given evolution to the effort required.

Maximum controllability is the rate at which an aeroplane performs a given evolution when the control surfaces are set over either to their maximum extent or to an extent which is limited by the strength of the pilot.

No attempt is made to lay down any rules as to what the "given evolution" referred to above should be in the cases of the different control surfaces. In view of the indefiniteness existing at present as regards any quantitative comparisons of controllability it would appear desirable that some convention should be arrived at in this connection. Taking aileron control, for instance, the criterion of controllability in roll might be the time to bank, say, 10 deg. when a given force is applied to the control column; and the criterion of maximum controllability the time taken to bank, say, 45 deg. when the control lever is set hard over. Experiment, however, is required to indicate what would be a fair criterion to adopt in each case; and it may be stated that experiments in this direction are in progress at the Royal Aircraft Establishment.

It is, of course, obvious that no comparison of the controllabilities of machines can be made without consideration of their maximum controllabilities, in fact, no strict comparison can be made at all unless the maximum controllabilities are the same or unless the importance of controllability and of maximum controllability are given relative values. And it is easily seen that the control of two aeroplanes may be identical while their controllabilities may be entirely different. Control depends upon the size, shape disposition, &c., of the control members and on the gearing between them and the control lever. Controllability, besides depending on these, depends on various aerodynamic characteristics of the aeroplane including stability and moment of inertia. Complete information as to control may be obtained from tests on control surfaces which give the moments they exert on the machine by their movement, and also the moments about their hinges. Such information is most conveniently obtained from model tests, and it is chiefly information of this nature which is given later in this paper. By its aid it should be possible, on the one hand, either to design a machine with reasonable certainty of obtaining any desired efficiency of control and any maximum control, or to estimate these for an existing machine. On the other hand, to design a machine with given controllability or maximum controllability, or to be able to estimate the controllability of a given machine is a matter of great difficulty. In the first place criteria of controllability would be required; given these, the estimation of controllability would, in general, be a laborious process requiring a full knowledge of the aerodynamical characteristics of the machine, and probably also, in many cases, the expedient of step-by-step integration. These considerations show it to be probable that the designing of control surfaces to give a specified controllability will not become everyday practice, at all events for some considerable time to come.

Experience with actual aeroplanes should, however, give a good idea as to the magnitude of maximum control and efficiency of control necessary for machines of various types in order that each type shall possess the degree of controllability desirable for that type. The difficulty in the past has been that there has not been sufficient information on which to estimate the maximum control and efficiency of control of any machine. Having this information, reports of pilots as to the controllabilities of different machines of given type could be studied in their relation to the maximum control and efficiency of control as estimated from model results, and a general conclusion arrived at as to the control desirable for any given type; quantitative full-scale experiments are, of course, particularly desirable in this connection.

Experimental Data.—Series of model experiments on control surfaces, in which length, breadth, shape, disposition, &c., are systematically varied, beside being useful as data on which to estimate the control of existing designs, should provide valuable general information as to the effect of changes in these variables. For instance, take a rectangular tail-plane of given size, for a given aeroplane. The best elevators for the machine, might be small elevators with a large range of movement, or they might be large with a small range of movement; only the results of a systematic series of experiments on the effect of variation of position of elevator hinge could decide.

A large number of experiments on control surfaces—chiefly model, but including a fair number of full-scale experiments—has been made in recent years at the National Physical Laboratory and the Royal Aircraft Establishment. These have resulted in valuable quantitative data, and have brought to light several points of practical importance finding general application in the design of control surfaces.

Model Experiments on Wing Ailerons.—The results of a systematic investigation of the aerodynamic properties of wing ailerons, made by the writer chiefly in conjunction with Mr. E. Ower, are given in Reports and Memoranda Nos. 550, 615 and 651, of the Advisory Committee for Aeronautics,* and it is these reports to which attention will be chiefly directed. Among the questions studied are the effect of variation of plan form, chord and span of aileron, and effect of gap between aileron and wing. The question of the balancing of ailerons was also taken up and important results obtained; space, however, forbids the inclusion of these in the present paper, but it is hoped that they may form the subject of a later paper.

It has been seen that the moments produced on the machine by movement of the control surfaces have to be considered both as regards their actual magnitude and as regards their relation to the effort required on the part of the pilot to produce them. This latter aspect of the question becomes most prominent in the case of large aeroplanes, in which it is important that the limited controlling force which the pilot can exert shall be used to the best advantage. The most common means adopted to this end is to "balance" the control surfaces. If, however, a machine is not very large and it is desired to make the control as light, or efficient, as possible without recourse to balancing, this may be done by adopting the size and shape of control surface which make for maximum efficiency of control. Accordingly, the experiments on ailerons referred to above were first directed towards finding the best shape of wing tip and the best span and chord of ordinary unbalanced ailerons from the point of view that the control should be as light as possible.

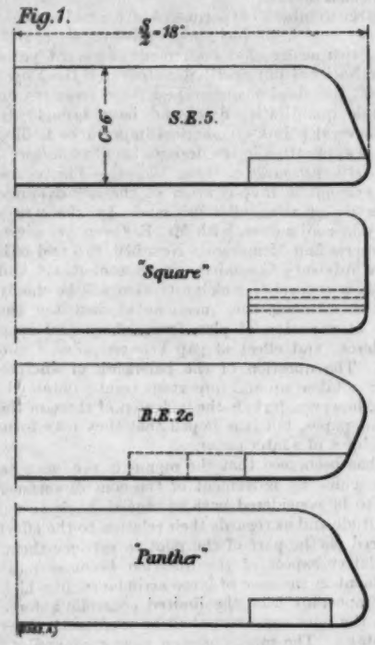
To this end measurements were made in the wind tunnel of rolling moment on a model biplane due to the ailerons, and of the moment about the hinge of the ailerons. It was convenient experimentally to confine measurements to the ailerons on one end only of the biplane. This procedure commended itself in that it gave separately the rolling and hinge moments due to upward and downward settings of the ailerons; and test experiments showed that there was no appreciable interference between the ailerons on the two sides of the biplane. What are actually required as the results of the measurements are, of course, the rolling moment on the biplane and the resultant hinge moment on the ailerons when they are up on one side and down on the other. It should be mentioned that the term "resultant" is not used here in its strictest sense; for in obtaining the "resultant" hinge moment from the moments on the two sides, the sign of one of them has to be changed owing to the manner in which the ailerons are connected to the control column of an aeroplane. Generally speaking, as far as the pilot is concerned, the resultant hinge moment is the numerical sum of the hinge moments on the two sides of the biplane.

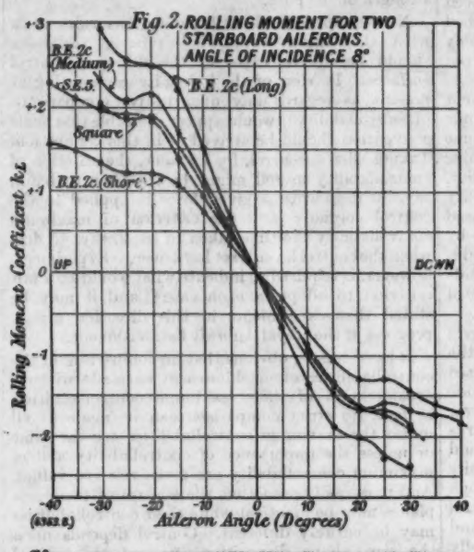
The first tests were made with ailerons fitted to wings of three different plan forms which are shown in Fig. 1. These are the original S.E.5 wing tips.

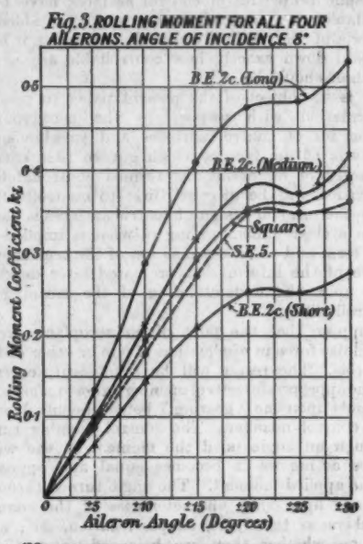
* Some of these Reports, as well as some others to which reference is made later, are not yet actually published, but are in the hands of the printer.

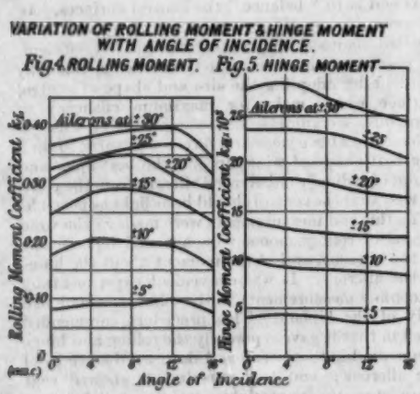
"square" tips with rounded corners, and B.E.2C. tips. Examples of the type of curve which is obtained when rolling moment is plotted against aileron angle are given in Figs. 2 and 3. Fig. 2 gives the rolling moment due to two ailerons on the one side of the biplane, while Fig. 3 gives the rolling moment for all four ailerons on wings of three different plan forms, the angle of incidence being 8 deg. These curves are in shape characteristic, not only of the curves obtained at 8 deg. incidence for ailerons of given chord on wing tips of various shapes, but, as the experiments showed, they are characteristic of ailerons of any span and chord (within the limits obtaining in practice) at any angle of incidence within the ordinary working range. of the working range of angle of incidence, and that the maximum rolling moment is of the order of 12 per cent. greater than the rolling moment at 0 deg. or 16 deg. incidence at which angles the rolling moments are generally not very different.

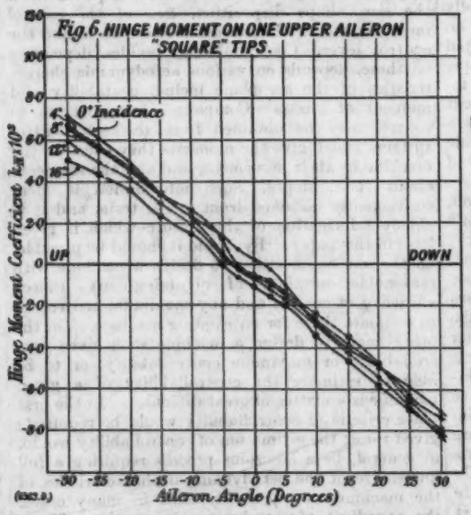
It should be mentioned that some measurements of rolling moment were made at angles of incidence as high as 18 deg. and 20 deg. These showed a progressive decrease in rolling moment with increase in angle of incidence above 16 deg., but in no case was there a reversal in the control either for upward or downward movements of the ailerons. This is in accordance with the results of experiments on model monoplanes with ailerons (A.C.A., R. and M., 152, II, Sections iii and iv., June 1914), in which Fig. 6, which applies to an upper "square" aileron for angles of incidence 0 deg., 4 deg., 8 deg., 12 deg. and 16 deg. These curves, again, are typical of the curves obtained for ailerons of various chords and spans on wings having various shapes of tip. It will be seen that, while the mean slope of the curves is about the same for all angles of incidence and that the curves—taking them along their whole length—do not depart very greatly from straight lines, there are generally several quick changes of slope. One of these changes, which appears to occur, in greater or less degree at all angles of incidence, is a decrease in the slope of the curve for small aileron angles. Taking this observation in conjunction with the fact that the curve of

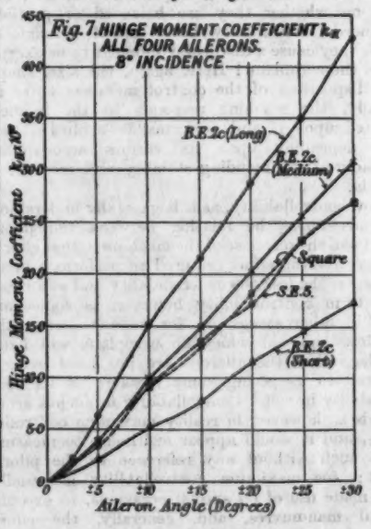












As will be seen from the curves, up to an aileron angle of 20 deg. (up or down) rolling moment increases roughly as aileron angle. At about 20 deg. a critical angle is reached above which the moment either decreases with aileron angle—generally increasing again at larger angles—or the increase in rolling moment with aileron angle becomes very small.

As has been stated, the type of curve of rolling moment against aileron angle does not alter materially with angle of incidence, but there are changes of slope, which are not very great, between one incidence and another. The extent of the variation of rolling moment with angle of incidence is illustrated by Fig. 4, in which rolling moment for given settings of the ailerons is plotted against angle of incidence for the "square" ailerons of Fig. 1. In general, it may be said that the rolling moment produced by a given setting of the ailerons is a maximum somewhere about the middle it was found that the control was not reversed at large angles of incidence up to 20 deg. unless the model was yawed. In the case of the monoplane the reduction in the control at large angles of incidence appears to be greater than in the case of the biplane. The curves which have so far been given as illustrations have all applied to upper and lower ailerons of a biplane moving together. Measurements made on upper and lower ailerons separately show that there is no great difference in their behaviour as regards rolling moment, and that the results when added together are very nearly equal to those for upper and lower ailerons moving together, thus showing that the interference between upper and lower ailerons is small.

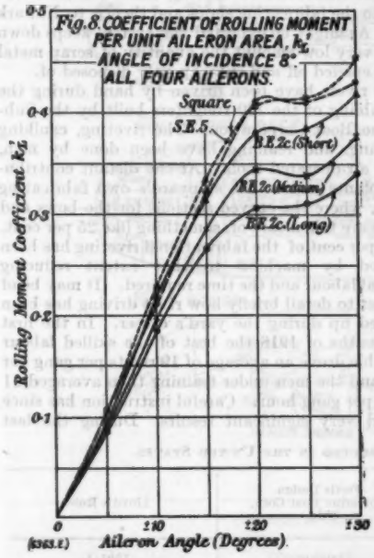
The above remarks as to similarity in behaviour of, and interference between, upper and lower ailerons apply also to aileron hinge moment. The type of curve which is obtained by plotting hinge moment against aileron angle is illustrated in rolling moment against aileron angle is almost a straight line near zero angle, it follows that the ratio of rolling moment to hinge moment is greater for small aileron movements than for big movements; this point is brought up again later in comparing the efficiencies of control of ailerons. Curves of hinge moment plotted against aileron angle are given for all four ailerons in Fig. 7, and variation of hinge moment with angle of incidence of the biplane is shown by Fig. 5. It will be seen that the variation with incidence is not great and that, in general, hinge moment decreases slightly as the angle of incidence increases.

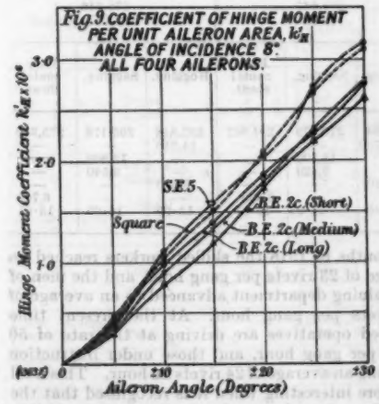
In giving the results of the measurements of rolling and hinge moment coefficients it has been thought advisable to express them in the form of non-dimensional coefficients such as will make the results more easily applicable to machines of any dimensions travelling at any speed. The form of coefficient chosen for rolling moment (L) is:

$k_L = L/\rho S C^2 V^2$

where ρ is the density of the air
S is the span of the biplane
C is the chord of the biplane
V is the wind speed

each being expressed in any consistent system of units such as pounds-feet for moment, slugs per cubic foot for density, feet for length, and feet per second for velocity. If the coefficients were to be applied only to biplanes and ailerons exactly similar to the ones tested, then, instead of $S C^2$, the cube of any dimension of the biplane would have served equally well. The purpose in choosing $S C^2$ was to make the coefficients applicable with more or less exactitude to biplanes of any aspect ratio, provided the coefficients are chosen for similar plan forms of wing tip and aileron. The assumption implied in applying such a coefficient as defined above to a biplane of any aspect ratio is that the flow of air over that part of the wing affected by a given aileron is independent of the





span of wing between the ailerons; if this is true, then L varies roughly as $S C^2$ for a given shape of wing tip and aileron.

Applying the same assumption as above to the case of hinge moment on ailerons of similar shape and similar wing tips, it follows at once that the form of the coefficient of hinge moment should not include the span S of the biplane. The form of coefficient k_H chosen for hinge moment H was then $k_H = H/\rho C^3 V^2$. Coefficients of the forms defined above, since they do not include any dimensions of the ailerons, are proportional to the actual moments for ailerons of different shapes and sizes fitted to a biplane of given span and chord. For general use, however, coefficients of a rather different nature, introducing aileron area, are perhaps to be preferred. Such coefficients which have been used are defined as follows:—

Coefficients of rolling moment per unit aileron area,

$$k'_L = L/\rho a S V^2;$$

coefficient of hinge moment per unit aileron area,

$$k'_H = H/\rho a C V^2;$$

where a is the total area of ailerons producing the moment L or H.

Curves of rolling moment per unit aileron area plotted against aileron angle for ailerons fitted to wings of the three different plan forms are given in Fig. 8. It will be seen that the curves for the "S.E.5" and "square" ailerons lie fairly close together, while the curve for the B.E.2c (short) ailerons is, on the whole, slightly below these curves. Fig. 8 also illustrates the falling-off in rolling moment per unit aileron area which occurs when the span of the aileron is increased, a falling-off which would naturally be expected to take place. Curves of hinge moment per unit aileron area are given in Fig. 9. Here, while the curves for the "S.E.5" and "square" ailerons are again in fairly close proximity, the curve for the "short" B.E.2c ailerons is considerably below them and the effect of increase in span is to increase the hinge moment per unit aileron area.

(To be continued.)

DEFECTS IN MOTOR VEHICLES AND THEIR REMEDY.

By F. Strickland.

(Continued from page 272.)

Back Axles.—There are four types of drive in common use for back axles: (1) Chain, (2) bevel, (3) worm, and (4) double reduction. In considering these it must be remembered that there is an essential difference between the light cars and the heavy lorries. In the former the gear ratio on the top speed is seldom greater than 4½ to 1, and it is quite practicable to get this with a single bevel. Accordingly the bevel gear is far the most common drive for a pleasure car. Worm drive has been used to a small extent in order to avoid noise, but the spiral bevel, which is coming into general use, can be made to run so quietly that the use of the worm is not extending.

In the case of the heavy lorry, however, the ratio of reduction has to be about 8 to 1 owing to the slower speed of the vehicle and larger driving wheels, and it does not appear practicable to make a satisfactory bevel gear of this ratio. Hence the choice is limited to arrangements (1), (3) and 4. Of these arrangements the chain drive is the oldest. It appeared to have many advantages for very rough work during the war, viz., great clearance in the middle of the axle, very direct pull on the wheel, ease of repair, and small unsprung weight. For commercial work, however, the live axle appears to be likely to become practically universal owing to there being fewer exposed wearing parts. The choice then lies between a worm drive on the back axle or a double reduction gear. The latter is usually arranged with a bevel-gear driving a countershaft and a spur drive from this to the axle.

Both these types of drive work excellently if well carried out, but as far as can be seen it appears that the worm has certain advantages over the double reduction. The latter entails an extra shaft with its attendant bearings, &c. This means greater cost of manufacture and also more wearing parts which may need replacement. It also generally means extra weight. Against this may be set the fact that the bevel and spur gears can be made entirely of hardened steel, and will, therefore, probably be more durable than the worm and wheel. The latter, however, proved extremely durable during the war, so that there is probably very little in this point.

It is possible that an exception to this may occur in very hilly countries. The pressure between the teeth of the worm and wheel in going up a steep hill is very high indeed, and it is possible that under these circumstances the double reduction gear may have advantages.

Back-axle casings are usually of two types. In the one the whole axle is a forging with a "banjo frame," to take the gearing, and there are castings bolted to the top and bottom of this, the one carrying the worm or bevel gearing, the other forming an oil cover. In the other arrangement the whole of the lower part of the axle is a steel casting with tubes pressed in or bolted on to form the wheel bearings.

The forged axle with the banjo frame has the advantage that there is one forging extending from wheel to wheel to take the weight, but in practice the steel casting seems to be coming into the most general use and appears to have some distinct advantages. It is probably the cheapest to make, and it is also easier in this type to make the wearing parts of the wheel bearings renewable. This is important as it is always possible for bearings to get scored from neglect, and it may be necessary to renew them. In the case of the cast axle this can be done by replacing the tubes, but in the case of the forged axle the whole forging must be replaced.

While the cast back axle works quite satisfactorily it seems that something better should be possible. Castings are necessarily heavy for their strength, and it is very important that unsprung weight should be kept as low as possible. In the light cars a great many axles are made of pressings of sheet steel, and it should be possible to make lorry axles in the same manner. If this were well worked out, a very considerable amount of weight could be saved, and at the same time a strong and reliable axle provided. Steel castings are always slightly liable to develop cracks under such vibration as an axle is subject to, and a pressing appears to be much more suitable.

Back Axle Shafts.—During the war there was a certain amount of trouble caused by driving shafts which connected the differential gear to the driving wheels twisting off. When the weight of the vehicle is not carried on the shafts, as is the case in some cars, and practically all lorries, the shaft is, of course, not subject to a bending moment, at all events theoretically, but only to twisting. This twisting moment is, however, very considerable, and some makers appear hardly to have provided a large enough margin of safety.

Both in one class of the very light cars and also in several of the 3-ton lorries, there were a considerable number of failures. These shafts form such a trifling proportion of the total weight of the axle, that it seems absurd to so cut down their size that they are not reliable. In some of the 3-ton lorries, for instance, these shafts were only 1⅞ in. diameter, and the stress when the clutch or brake is applied suddenly was very high indeed. To make them 2½ in. diameter would only entail an extra weight of 15 lb. to 20 lb., while the stress would be reduced to about two-thirds.

Back Axle Suspension.—In the case of live-axle vehicles the attachments of the back axle to the frame have to provide for two different forces in addition to carrying the weight. Firstly, the driving force which propels the lorry. Second, the torque of the axle itself. There are four methods in common use for taking these: (1) Radius rods to take driving force; separate torque rods to take torque. (2) Tubular member round propeller shaft, to take both driving force and torque, fixed in ball and socket joint at front end. (3) Driving force taken by the springs and separate torque rod. (4) Both driving force and torque taken by the back springs.

In the first two alternative arrangements the back springs have shackles at both front and back ends; in the latter two they are fixed at the front and have shackles at the back only.

Comparing these methods of construction there are two points to be considered. Firstly, the theoretical points which largely determine the weight. Second, the practical cost of upkeep. Regarding the first point, it must be borne in mind that the forces from the back axle have eventually to be transmitted to the side members of the frame, and further, that the propelling force of the vehicle originates at the wheels. It is, therefore, obvious that, theoretically, the drive should be taken from the axle as near as possible to the wheel track and transmitted as directly as possible to the side members of the frame. This condition is fulfilled as regards the propelling force by Nos. 1, 3 and 4

of the above arrangements. In the case of No. 2, however, the propelling force is taken from the centre of the axle and transmitted to the centre of a cross-member of the chassis, and accordingly a considerable bending moment is put on the back axle as well as on this cross-member.

In the case of light cars, the bending moment on the axle is often avoided by having diagonal struts from the ends of the axle to the front of the torque tube as in the Ford, and the propelling force is so small that there is no trouble in making the cross-member of the frame strong enough without undue weight. In the case of lorries, however, the propelling force may approach two tons, and the cross-member and its attachments must be heavy enough to take this. In France there were several cases of the cross-members cracking or the fastenings working loose.

Lorry live axles of the ordinary cast steel patterns have usually ample strength as they cannot be cast less than a certain thickness, but it is to be hoped that some lighter form of live axle will be developed, and in this case the fact that when arrangement No. 2 is used the bending moment due to the propulsion of the vehicle is far greater than that due to the weight may be of some importance.

With regard to the torque it is obvious that the only practical way of transmitting this direct to the side member of the frame is No. 4. This is, however, not an important point as the torque load on the cross-member is not very great and a very light cross-member will take it. A point of greater importance, especially in the heavy vehicle, is that a tube is not the best form to take a bending moment, hence if a tubular torque rod is used on No. 2 it must be heavier than when a specially shaped torque rod is used. Theoretically, therefore, No. 2 should be the heaviest construction. With regard to the others there should not be a great deal of difference, but No. 4 is probably the lightest in practice, in lorries at all events, as it is not found that springs which take the drive and torque have to be materially heavier than those taking load only, and the weight of torque and radius rods is saved. When a separate torque rod is used the spring seats must also be free to rotate on the axle and this involves extra weight.

With regard to the practical question of cost of upkeep there is a great difference in the number of wearing parts in these systems, there being in :—

	Wearing Parts.
No. 1	16
No. 2	11
No. 3	10
No. 4	6

Thus No. 4 has only two shackle pins and the pin at the front of the spring at each side, while No. 1 has the springs on shackles at both ends entailing an extra pin each side, and in addition has the pins of the radius rods and the links of the torque rod and also has spring seats revolving on the axle. All these parts require lubrication, and periodical renewal, and, therefore, the cost of upkeep should be, *prima facie*, fairly proportionate to the number of wearing parts.

In light cars a set-off to this is the fact that one universal joint is saved, and the other is well lubricated and enclosed, while the system works well with cantilever springs which are coming into considerable use. In the heavier vehicles, however, it is usual not to bring the torque tube right up to the gear-box, but to fix it to a cross-member some distance behind this so that there are two universal joints in any case.

Reviewing the question as a whole, it seems that in the heavier vehicles No. 4 has certainly the balance of advantages being for a given strength distinctly lighter and cheaper to build, and having the smallest number of wearing parts and, therefore, the lowest upkeep. For the same reasons No. 3 should be better than either No. 1 or No. 2.

In the lighter type cars the same reasoning will probably apply where semi-elliptic springs are used, but the tendency is to use cantilever springs and then No. 2 is probably most suitable. It also makes a very "clean" looking chassis, which is a matter of considerable importance in sales.

(To be continued.)

THE FUTURE OF THE FABRICATED SHIP.

Of the three yards called into being during the period of the war to build fabricated ships in America only one is bent upon continuing in the business and planning to amplify its facilities. The Submarine Boat Corporation has taken over from the Government the great plant of the Newark Bay shipyard upon a four-year lease with the right to acquire permanent possession at the end of that tenure. Further, the programme provides for extensive development of both the yard and its immediate neighbourhood, with the idea of making that point a port of entry and departure which will be equipped with loading and unloading facilities of the most approved design, so that incoming and outgoing freight can be dealt with without delay in moving to and from the several trans-continental railways focussing nearby.

The purpose is also to supplement the existing shipbuilding establishment by creating dry docks and other repair conveniences, and to make it practicable to cut down to a minimum the turn-around period of freight steamers, so that vessels using that base may be operated under conditions that will bring in the largest possible return upon the allied ventures. In brief, the determination is to put to profitable account, in the various departments of maritime industry, the lessons learned through that system of co-ordination which made the fabricated cargo craft possible.

The steamers constructed at the Newark Bay shipyard have made excellent records for themselves, taking their service performances by and large, and they have demonstrated that the methods of the bridge builder can be applied effectively, economically, and successfully in the realm of marine architecture. The standpipe test of 34½ ft. has in no wise taxed the men who have in the past fashioned steel flumes for water-power projects in which the hydrostatic heads were of 1,000 ft. and more. The assistant manager of the Division of Construction and Repair of the United States Shipping Board has recently stated that the hulls of the steamers produced at Newark Bay are recognised as among the best built of any of the freighters now in service.

Reports made by masters and chief engineers of these particular craft reveal the soundness of the hulls and their unusual tightness and freedom from leakage in the cargo bilges, &c. This has been especially evidenced when some of the craft have been dry-docked with their liquid fuel tanks filled. Without exception there has been no external indication of seepage despite the searching character of oil.

In the construction of these boats the mild steel commonly employed in structural operations ashore has been used—this procedure constituting a departure from the usual marine practice. The vessels so fabricated have shown themselves capable of withstanding to a marked degree very rigorous treatment—in cases of collision and grounding the soft steel has been found to bend but to remain otherwise intact where harder steel would be apt to break. This yielding has prevented flooding of the holds on a number of occasions. A fairly typical example is that of the s.s. Hillsborough County, operated by the Ward Line between New York and the West Indies. The ship, when rather light, was caught in a hurricane and driven ashore at Maya Point, Cuba. For more than three months the steamer was exposed to the buffeting of the seas, and when finally floated free she was found sound. She was permitted to steam for Baltimore under her own power. Many a vessel of the usual build would have gone to pieces under similar conditions.

The belief has prevailed that the peace time adoption of fabricational methods in shipbuilding would involve too large a loss due to misfits; and it has been claimed that transportational costs would mount up prohibitively owing to the scattered positions of contributive plants. At Newark Bay out of 50,000 pieces, for example, delivered there not more than seventy proved to be misfits, and these varied so little from the specifications that most of them could be easily corrected. The maximum tolerance allowed in hull units is 1-16th of an inch. Again, the railroads grant to the shipyard a "mill-in-transit rate," which minimises the expense incidental to moving materials from the mill to the fabricating shops and thence to Newark Bay. As might be expected the system keeps down to a very low amount the quantity of scrap metal to be carried off and subsequently disposed of.

No rivets have been driven by hand during the assembling of the 120 freighters built by the Submarine Boat Corporation. The riveting, caulking chipping, and reaming have been done by men, using air-operated tools. At the distant contributive plants and at the shipyard's own fabricating shops, where the curved sections for the bows and sterns are taken care of, something like 25 per cent. to 35 per cent. of the fabricational riveting has been effected by machine—to that extent reducing manual labour and the time required. It may be of interest to detail briefly how rivet driving has been speeded up during the yard's career. In the first six months of 1918 the best of the skilled labour available drove an average of 19 rivets per gang per hour and the men under training then averaged 11 rivets per gang hour. Careful instruction has since yielded very significant results. During the last six months of 1918 the skilled workers reached an average of 23 rivets per gang hour, and the men of the training department advanced to an average of 12 rivets per gang hour. At the present time qualified operatives are driving at the rate of 56 rivets per gang hour, and those under instruction are doing an average of 24 rivets an hour. This is all the more interesting when it is recognised that the urge of war is no longer the inspiration for speeding up production.

Plainly, standardisation, a well-worked out sequence of erection, and the adoption of a carefully planned "berthing system"—by which each hull is subdivided into definite job areas for piecework compensation, have brought about a permanent rate of rivet driving much above that to be found in ordinary commercial practice. Excellence of performance has kept pace with this expedition of execution.

Because of the employment of manufacturing methods, in all departments of the fabricated ship, time and effort are economized. The motive plant, the auxiliaries, and multiple standardised fittings go into their designated places quickly. The water-tube boilers furnished these vessels lend themselves to assembling aboard while the hulls are on the blocks; and piping and other connections are

Data Relating to Fabricated Ships Constructed in the United States.

Section.	Unit.	Ferris Design Submarine Boat Corp. Ship.			Lloyd's Rule.		
Net area of section	Square inches	1420·9			1391·1		
Net moment of inertia of section	Sq. in. by sq. ft.	294,967			275,346		
Statical moment for horizontal shear	Sq. in. by sq. ft.	9,705			9,185		
Condition.		**Hogging.**	**Sagging.**	**Horizontal shear.**	**Hogging.**	**Sagging.**	**Horizontal shear.**
Corrected moment of inertia of section	Sq. in. by sq. ft.	314,984	316,679	294,967	292.848	296,176	275,346
Tension in bridge deck shear strake	Lbs. per sq. in.	12,750	—	—	14,210	—	—
Compression in bridge deck shear strake	Lbs. per sq. in.	—	11,500	—	—	12,800	—
Tension in keel	Lbs. per sq. in.	—	9,420	—	—	9,540	—
Compression in keel	Lbs. per sq. in.	8,270	—	—	8,520	—	—
Shear in rivets—Shell lap G. H.	Lbs. per sq. in.	—	—	6,660	—	—	6,760
Height of neutral axis above base line	Feet	14·8	16·94	15·87	13·99	16·05	15·01

THE CONSTRUCTION OF FABRICATED SHIPS IN THE UNITED STATES.

Fig. 1. INBOARD PROFILE.

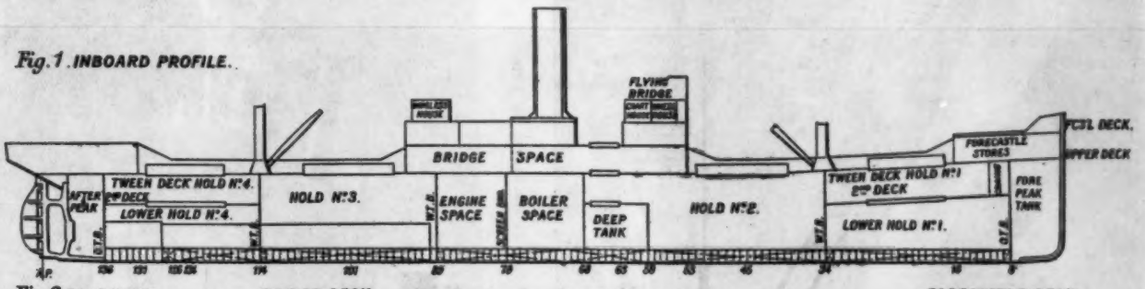


Fig. 2. POOP DECK. BRIDGE DECK. FORECASTLE DECK.

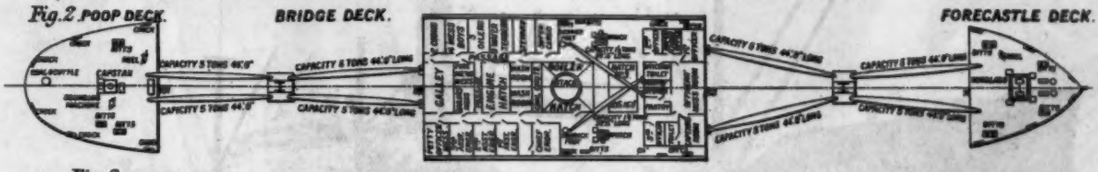


Fig. 3. UPPER DECK.

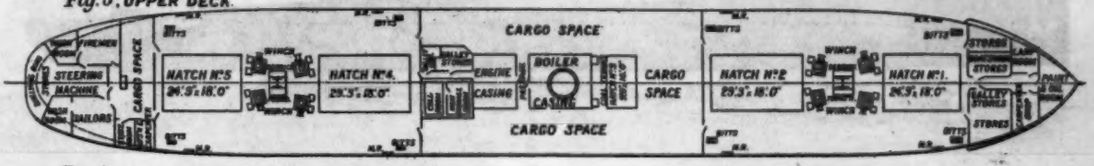
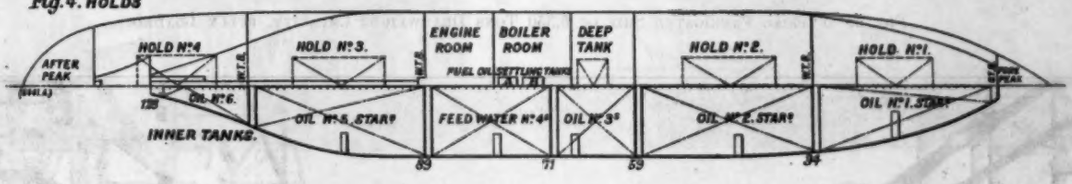


Fig. 4. HOLDS



Capacities of Cargo Spaces.

Hold No.	Section.	Dimensions for Bales. Depth.	Maximum Length.	Maximum Breadth.	Capacity (Bales) Cub. Ft.	Capacity (Bulk Grain) Cub. Ft.
		ft. in.	ft. in.	ft. in.		
1	Upper ..	9 2	57 10	43 4	19,700	22,400
	Lower ..	14 6	57 10	43 4	29,300	34,340
	Total ..	—	—	—	49,000	56,740
2	Over tank ..	8 9	20 0	43 8	7,600	10,000
	Main body ..	23 8	55 8	43 8	56,900	65,500
	Total ..	—	—	—	64,500	75,500
3	Total ..	23 8	55 8	43 8	53,950	64,200
4	Upper ..	8 9	40 1	43 8	13,500	18,900
	Lower ..	13 6	40 1	42 0	8,800	11,820
	Total ..	—	—	—	22,300	30,720
Under bridge deck	Total ..	7 6	(Irregular) 89 0	43 8	22,800	25,840
Under poop deck	Total ..	10 11	29 0	8 10	2,300	2,800
Deep tank ..	Total ..	14 1	18 3	43 9	11,300	13,800
	Total capacity				226,150	269,600

Double Bottom and After Peak Tanks.

Description.	No.	Location.	Capacity. Cub. Ft.	Gallons.	Pounds.
Fuel oil ..	1P.	Fr. 9 to 33 ..	2,532	18,930	139,360
	1S.	Fr. 9 to 33 ..	2,532	18,930	139,360
	2P.	Fr. 34 to 58 ..	3,904	29,200	214,720
	2S.	Fr. 34 to 58 ..	3,904	29,200	214,720
	3P.	Fr. 59 to 70 ..	1,784	13,340	98,120
	3S.	Fr. 59 to 70 ..	1,784	13,340	98,120
	5P.	Fr. 89 to 113 ..	3,301	24,680	181,555
	5S.	Fr. 89 to 113 ..	3,301	24,680	181,555
	6	Fr. 114 to 126 ..	1,068	7,980	58,740
	After peak		2,480	18,520	136,400
	Total		26,590	198,800	1,462,450
Feed water ..	4P.	Fr. 71 to 88 ..	2,772	20,730	173,250
	4S.	Fr. 71 to 88 ..	2,772	20,730	173,250
	Total		5,544	41,460	346,500
Total capacity, fuel oil and feed water ..			32,134	240,260	1,808,950
Fresh water tanks			936	7,000	58,300
Fuel oil settling tank "A"			526	3,930	28,900
Fuel oil settling tank "B"			581	4,340	31,050

NOTE.—All dimensions used in figuring cargo holds are taken inside of timber ceilings and 2 in. under bottom of deck beams—for bales. Deduction made for shaft alley and alley flat. Capacities for bulk grain are figured to moulded lines at top and sides, and to tank top ceiling, minus all obstructions.

Coal Bunkers.

		Cub. Ft. None.
Permanent bunkers		
Convertible bunker space	Deep tank	13,800
	Cargo space under bridge deck	25,840
Total	.. ..	39,640

Trimming Tanks.

Location.	Cub. Ft.	Gallons.	Tons.
Deep tank	13,800	103,170	394
Fore peak	3,882	29,037	111

Hatches and Booms.

Hatch No.	Size of Hatch.	No. of Booms Serving Hatch.	Capacity of Booms.
	ft. in. ft. in.		
1	24 9 × 18 0	2	5 tons each
2	29 3 × 18 0	2	5 tons each
3	9 0 × 16 0	2	1½ tons each
4	29 3 × 18 0	2	5 tons each
5	24 9 × 18 0	2	5 tons each

	Ft. In.
Holds—	
Length overall	335 6
Length between perpendiculars	324 0
Breadth moulded	40 0
Depth moulded at sides	28 6

Underdeck tonnage assigned by United States Customs Officials = 3,004·70.

To tank top only = 3,922·80.

Gross tonnage	= 3,545
Net tonnage	= 2,174

NOTE.—The figures in these tables are the builder's, and are given in good faith but without guarantee of accuracy.

THE CONSTRUCTION OF FABRICATED SHIPS IN THE UNITED STATES.

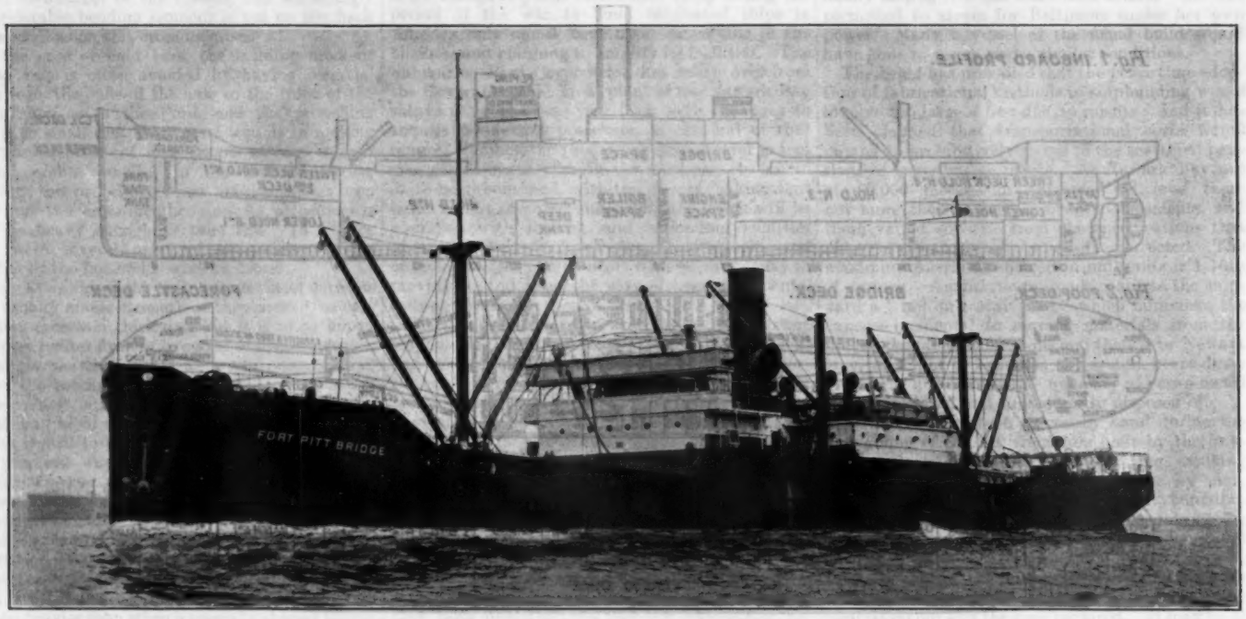


Fig. 5. Typical Fabricated Ship of 5,350 Tons Deadweight Capacity, fully Loaded.

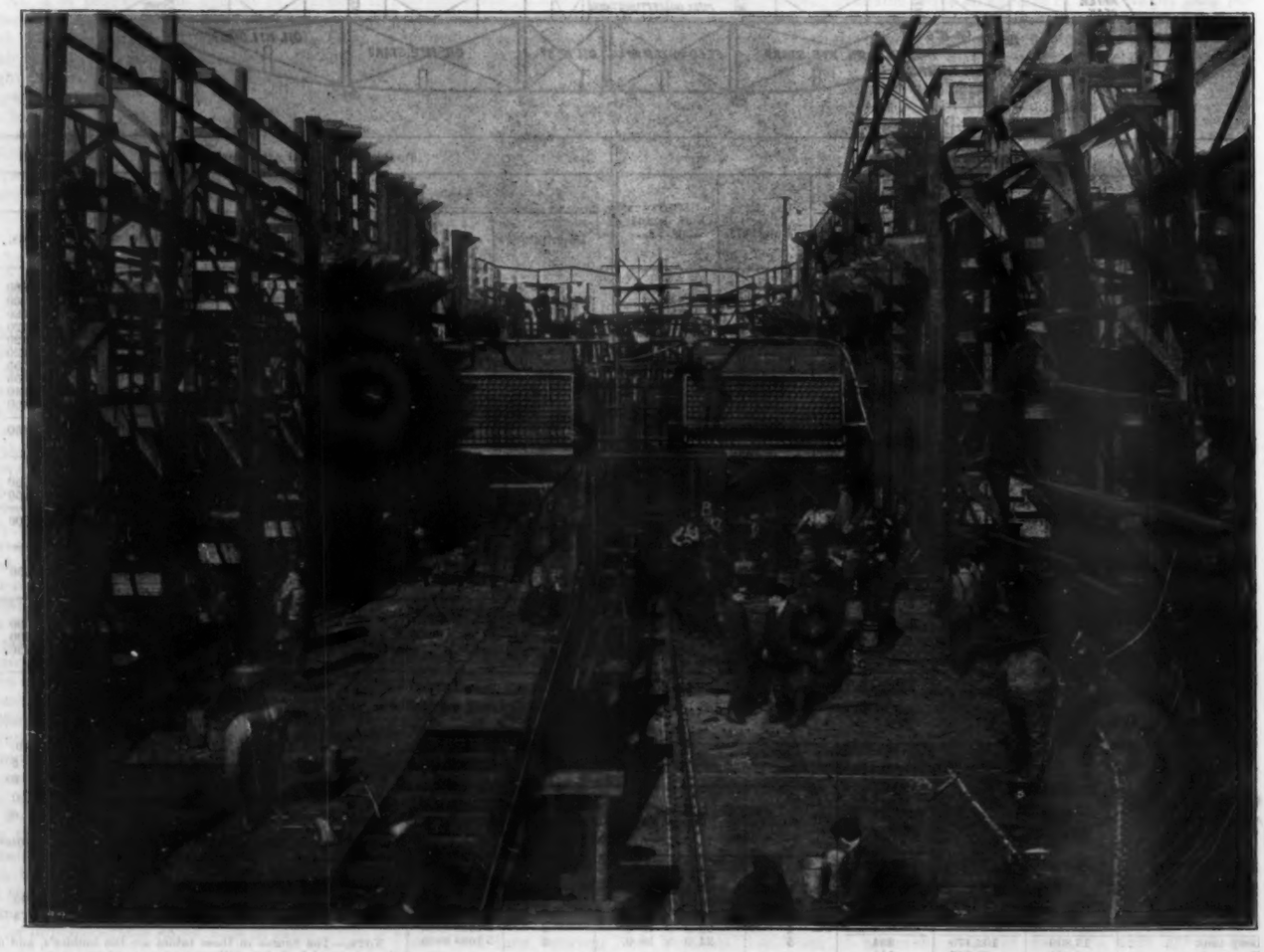


Fig. 6. Installing the Water-Tube Boilers on Board a Standardized Fabricated Ship.

THE CONSTRUCTION OF FABRICATED SHIPS IN THE UNITED STATES.

FIG. 8. FINISHED STERN FRAME AND SHAFT SUPPORTS AS RECEIVED AT YARD.

FIG. 10. A FABRICATED, FRIGHTER BEFORE LAUNCHING.

FIG. 7. STOREYARD FOR INTERCHANGEABLE PARTS AND EQUIPMENT.

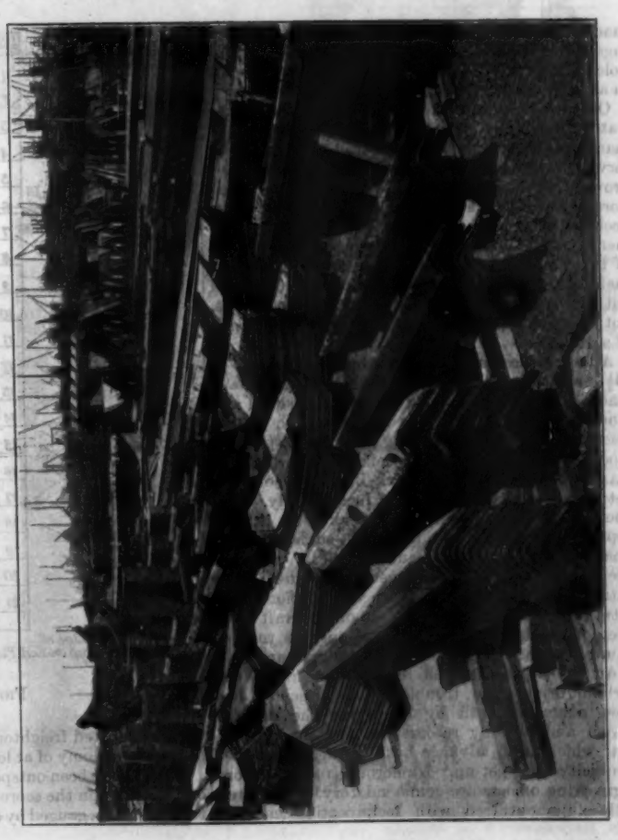


FIG. 9. FABRICATED PARTS AS RECEIVED AND STORED IN MATERIAL YARD.

THE CONSTRUCTION OF FABRICATED SHIPS IN THE UNITED STATES.

Fig. 11. View of the Wet Basin of the Newark Bay Shipyard.

made with little or no trouble, simply because openings through bulkheads and associate bolt or rivet holes are bored precisely—identical hull parts being in all respects interchangeable.

Objection was raised at first to the adoption of the water-tube boiler. Conservative members of the maritime fraternity were opposed to them. In service, however, these steam generators have proved efficient and quite satisfactory. Their normal repairs are such that the men usually below deck can meet all requirements in effecting replacements, &c. On numerous occasions, the capacity of the water-tube boilers to raise promptly and to maintain a maximum head of steam has been of outstanding value when battling with head seas, not to mention the cutting down of the duration of a voyage.

Although designed for a maximum sea speed of 10½ knots, the 5,350-ton deadweight steamers have made, again and again, long trips at a rate of 11 and more knots an hour. This has been due to the reserve power in the propelling plant and to the hull model which has a block coefficient of ·78. At maximum speed, these Newark Bay craft consume between 20 tons and 21 tons of fuel oil daily. The double bottoms and the after peak tank have a capacity of 710 tons of liquid fuel—sufficient for a steaming radius of 9,000 nautical miles. With the deep tank filled, as an emergency measure for an extra long voyage, the boats are self-sufficient for a total run of 13,000 knots. Some of the craft have averaged a daily consumption of only 18 tons of liquid fuel when making their full designed speed.

At the beginning, the reduction gears of the turbine drive gave trouble. This difficulty has been overcome both by modifying the original design and also by recourse to another type of gear which is an advance both in ruggedness and simplicity of get-up. Numerous reports from engineering officers are commendatory. Compared with ships outfitted with reciprocating engines,

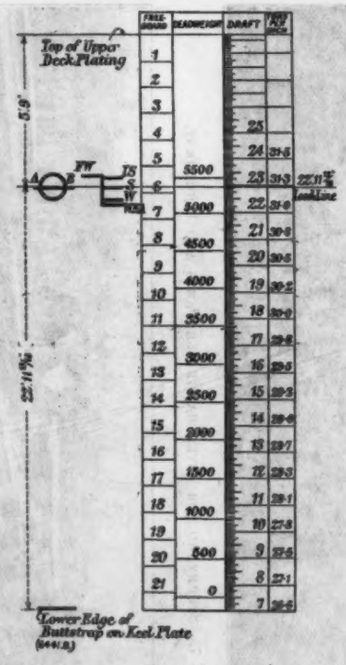


Fig. 12.

these fabricated freighters are, it is stated, showing a motive economy of at least 15 per cent.

Critics have been outspoken against the fabricated cargo carrier on the score of greater weight in structural make up, gauged by ordinary marine standards. It is true that these 5,350-ton deadweight vessels are about 35 tons heavier than craft of similar capacity of the same general dimensions built in strict accordance with Lloyd's rules. This difference is about equal to 2 per cent. of the weight of the steel in the ship, or to about two-thirds of 1 per cent. of the craft's deadweight carrying capacity. The seeming objection to this added weight is neutralised by the gain in hull strength. There are reasons to believe that this factor makes for the ability to withstand more rigorous treatment in service while probably adding to length of life. The table given on page 464 is suggestive.

This whole subject of the manufactured, standardised merchant ship has its revolutionary aspects, and while there are ship owners in plenty who may prefer to have their bottoms built more strictly along old-established lines, still the innovation is entitled to its measure of consideration. It undoubtedly represents in marine architecture what the multiple production of the automobile, and agricultural machinery, &c., stand for in other departments of industrial life. The crucial problem, of course, is a ready market.

The fabricated freighter has now been afloat long enough, to experience sufficiently varied conditions to reveal its seaworthiness. It is a well-known fact that steamers of this kind have been able to forge ahead in the teeth of storms that have driven larger boats of the usual build to leeward. It is also true that their sound hulls have permitted them to deliver their cargoes of sometimes rather easily damaged freight in an unharmed state after protracted and tempestuous voyages. Finally, structural ruggedness will inevitably minimise the annual cost of repairs. This applies to any sturdy and carefully-fashioned craft, but seems to be a pretty uniform characteristic of the ships in question.

Because of the standardisation of every feature of the fabricated cargo carrier, replacements in cases of breakdown or injury can be made very promptly

if the vessels are anywhere near their home yard. The Newark Bay plant is stocked with manifold parts and auxiliaries ready to be worked into new ships or available for a boat needing attention of any sort. Without elaborating upon this part of the subject, a single instance will suffice to show the value of the new system.

Two steamers, one a Newark Bay product, collided head-on in New York harbour, and each smashed a hawse pipe. The fabricated ship was able to have her damaged pipe cut out and another substituted from stock in the course of a few hours. The less fortunate vessel was laid up for something like six weeks while a pattern was made, a casting moulded and machined, and the new hawse pipe set in place and secured. It is evident that the manufactured steamer will be less hampered in getting back to actual service whenever she needs overhauling of any sort and can draw upon her building yard for ready-made replacements.

As might be expected, in view of the circumstances in which the fabricated craft was called into being, these ships did at first develop minor features not entirely satisfactory to the sea-going fraternity. Their builders have heeded all intelligent criticisms, and to-day the Submarine Boat Corporation is making every effort to construct boats that will satisfy any rational demand without, of course, departing from the fundamental idea or get-up of the type.

In connection with this article we give on page 465 engravings, Figs. 1 to 4, and tabulated particulars of the standardised type of vessel, of 5,350 tons deadweight capacity, to which reference has been made, a photograph of one of these vessels being also given in Fig. 5, on page 466. The other view, Fig. 5, on the last-named page, shows the installation of the water-tube boilers in one of these vessels, while the four illustrations, Figs. 7 to 10, on page 467, give a good idea of the manner in which the fabricated parts are dealt with. A general view of the wet basin of the Newark Bay shipyard is given in Fig. 11 on the opposite page, while Fig. 12 shows the relation between the draught and deadweight carried.

Looking to the near future, the company is developing a Diesel engine equipment for some of its 5,350-ton ships now under way. There are two of these experimental installations in hand; one of six cylinders to develop 2,000 h.p., which will be direct-connected to the propeller shaft, and another design of 1,500 s.h.p., which will consist of an oil-electric drive. The flexibility of the latter arrangement is considered to give promise of being of economic value in operating mercantile vessels.

The Submarine Boat Corporation has also prepared plans for fabricated steamers of greater as well as of lesser displacements than the model in which it has heretofore specialised. Up to April 1 of the current year 120 craft had been launched from the 28 ways of the Newark Bay shipyard. The keel of the first boat was laid on December 20, 1917, and that vessel was launched on May 30 following. The record in the interval is unique in the annals of the shipbuilding yard. It is because of this showing and the manner in which the boats have met service demands that the company is determined to carry on and is embarking in the actual operating of steamers of its own constructing.

Water Towers of Ferro-Concrete.—During the war the firm of Dyckerhoff and Widman built several large water towers of ferro-concrete for chemical works, which were described by Spangenberg in the journal *Der Bauingenieur*, of April 30, 1920. Some particulars of one of the largest towers, built in ferro-concrete, are given in an illustrated article by W. Knopp, in the *Zeitschrift des Vereines Deutscher Ingenieure*, on page 748 of the issue of September 11. The tower proper has a height of 50 m. (164 ft.), but the tank on the top brings the height to nearly 200 ft. The 10 main columns are arranged in a circle about 15 m. (50 ft.) in diameter and are interconnected by horizontal rings; the ring walls are outside the columns. The circular base, a concrete block 1·5 m. (5 ft.) thick, has a diameter of 19·4 m. (about 69 ft.), which also serves directly as a bottom for the lower cistern, which is partly underground and has a capacity of 500 cub. m. (17,660 cub. ft.). Higher up inside the tower three more cisterns were provided, with capacities of 200 cub. m., 500 cub. m., and 1,000 cub. m. (respectively 7,060 cub. ft., 17,660 cub. ft. and 35,300 cub. ft.), and a fourth cistern of 65 cub. m. was finally added between the underground cistern and the next one above.

THREE-PHASE ELECTRIC LOCOMOTIVE FOR THE ITALIAN STATE RAILWAYS.

In 1914 the Italian State Railways placed an order for six three-phase 4-6-4 type electric locomotives with the firm of Construzioni Meccaniche di Saronno, of Milan, for which the electrical equipment was supplied by the Oerlikon Works Company. The Italian State Railways designed the mechanical parts and specified the following speeds, &c., with a working voltage of 3,300 and a frequency of 16⅔ periods per second.

Speed in km. per hour ..	37·5	50	75	100
Speed in miles per hour ..	23	31	46	62
Continuous rating in h.p. ..	1,350	1,670	2,640	2,220
Draw-bar pull in kg. ..	9,000	9,000	9,500	6,000
Draw-bar pull in lbs. ..	22,000	20,000	21,000	13,000

Maximum draw-bar pull in kg.	12,000
Maximum draw-bar pull in lbs.	26,000

The engines, one of which is illustrated in Fig. 1, below, have six coupled wheels, 1,630 mm. (64 in.), and bogie wheels 960 mm. (38 in.), in diameter, and an overall length of 13,370 mm. (44 ft.). The total wheel-base is 10,600 mm. (35 ft.), but the rigid wheel-base is only 3,600 mm. (12 ft.), so that the locomotives

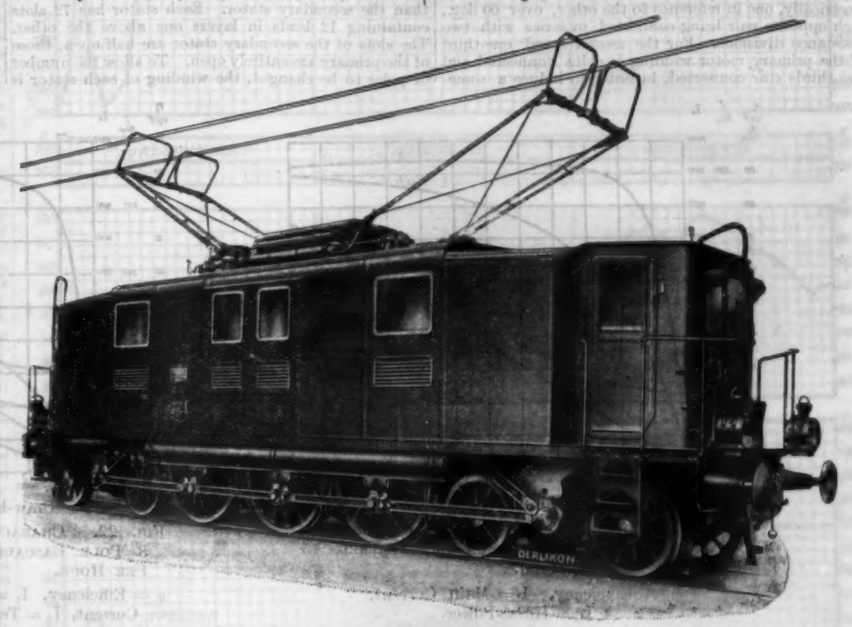


Fig. 1.

can take curves at high speed. The driving axles have no side play, but the bogies are allowed a lateral movement of 50 mm. (2 in.), being controlled by volute springs. The bogie wheel-bases are 2,000 mm. (6 ft. 4 in.) and the distance between the bogie centre pins is 8,600 mm. (28 ft.). The total weight of each locomotive is 92 metric tons (90 British tons), of which 42·7 tons represents electrical equipment. The weight on each driving axle is 18 tons, and 54 tons are available for adhesion.

The main frames are built up of 32 mm. (1¼ in.) plate connected with cross-bearers, stays, &c. Strong U-shaped body bolsters carry the bogie centres and the side bearings for the auxiliary shafts. The driving axle springs are equalised, but those of the bogies are independent. A diagonal connecting rod from the motors has been adopted, as is best shown in the elevation of the machine given in Fig. 2, on Plate LIX, but the length of the engine made it possible to arrange for auxiliary cranks over the bogie centres, with their centres only 20 mm. (¾ in.) higher than the driving wheel centres. The inclination of the connecting rods is 33 deg. The arrangement is well shown in Fig. 2. The coupling rods are provided with universal joints. Westinghouse brakes are fitted to all coupled and bogie wheels, there being three brake cylinders, one for each bogie and one for the coupled wheels. The braking pressure, with air at 3·5 atmospheres, is 60 per cent. of the weight available for adhesion in the case of the coupled wheels, and 35 per cent. in the case of the bogie wheels. Hand brakes and Leach air-sanding gear are fitted to the coupled wheels. The cab, or body, is rather shorter than the main frame. End compartments are arranged for the driver, and the motor control gear and all high-tension apparatus is separately enclosed. The motors are fixed to cast steel frames extending between the main frame plates, and are held in place by bolts and adjustable wedges.

The general lay-out of the main apparatus on the locomotive will be followed from Figs. 2 to 8, on Plates LIX and LX. The motors are arranged symmetrically about the centre line, and outside of each there is a compartment. One contains the high-tension gear and the other two motor compressor sets. The space between the motors is occupied by resistances and control gear. The pole-changing switches are carried at the top of the motors on the left-hand side of the locomotive, and the cascade switch is fixed at the same level and above the resistances. This arrangement, which is illustrated in Fig. 2, keeps down the number and length of the various connections between the motors, switches and resistances and allows of a common drive for the pole changing and cascade switches. Two motor-driven fans supply cooling air for the resistances and main motors. They are placed underneath the resistances and between the frame plates in a ventilating duct. Air is drawn through the main motors, is driven through the resistances, and escapes through louvres in the roof. The door of the high-tension compartment is interlocked with the gear which controls the raising and lowering of the current collector, so that no access can be had to the compartment while the collector is up.

The high-tension compartment contains a main oil switch with no-volt and overload release, the necessary instrument transformers, induction coils and lightning arresters, and four single-pole earthing switches. There is also a second oil switch which controls the high-tension motor circuits only. In circuit with this oil switch there is a reversing switch which controls the direction of travel of the locomotive. The compartment also contains two transformers for supplying the auxiliary machinery. These are protected by two overload oil switches. The driver's compartment contains the necessary handles for operating the pneumatic control of the main electrical machinery, various indicating and recording instruments and switches for the compressor set, &c. The compartment also contains an electric heater. These various pieces of apparatus, with their connections, are shown in Figs. 9 to 13, on Plate LXI. As will be seen the main connections are carried from the reversing switch to the terminals of the cascade switch. Depending on the position of the latter, the current is supplied to one main motor, or to both. Various illustrations of the motors and other electrical gear are given in Figs. 14 to 20, on Plate LXII.

The rails form the conductor for the third phase, connection to the motors being made through the wheels of the outer driving axles, which are fitted with earthing slip-rings. The collecting brush is secured to an arm carried by a copper rail bolted to the locomotive frame. The details of this earth connection are illustrated in Fig. 20. The four running speeds of the locomotive are obtained by a combination of changes in the pole connections of the stator windings

with cascade or parallel connections of the motors. The number of poles can be six or eight, and the change is obtained by inverting the pole switch, the cascade switch controlling the supply to the motors and their connection one to the other, and with the starting resistance. The various connections are as shown in Figs. 10 to 13, on Plate LXI, and the corresponding synchronous speeds are as follows:—

Fig. 10. Motors with eight poles connected in cascade, 37·5 km. per hour.

Fig. 11. Motors with six poles connected in cascade, 50 km. per hour.

Fig. 12. Motors with eight poles connected in parallel, 75 km. per hour.

Fig. 13. Motors with six poles connected in parallel, 100 km. per hour.

The cascade connections are such that the stator of the forward, or primary, motor is supplied from the system, while its rotor is connected in series with that of the rear or secondary motor, and the stator of the latter is connected to the resistance. The rotor of the secondary motor thus acts as the inducing unit, and its stator as the induced unit. As will be seen from Fig. 10, the winding of the primary stator for the first speed is three-phase, while that of both rotors is six-phase star-connected. The corresponding winding of the secondary stator is in six parts shifted electrically, one in reference to the other, over 60 deg., each opposite pair being connected in series with two resistance divisions. For the second speed one-third of the primary motor winding is delta connected and two-thirds star connected, in order to induce a somewhat higher pressure in the primary motor, and consequently in the secondary stator. The winding of both rotors is two-phase connected, and the secondary stator is connected to the resistance in the same way as in the case of the first cascade connection. For the two parallel connections both stators are supplied from the system, and the rotors are in parallel and are connected to the starting resistance. Apart from the number of poles, the two parallel connections differ from each other in that for the third speed the rotors are connected six-phase and for the top speed they are connected two-phase. Both stators are three-phase star-connected.

The starting resistance is disconnected in steps, both at starting and speed changing. The disconnection is carried out non-symmetrically for the six resistance sections and in 16 steps for the first three speeds. For the speed of 100 km. per hour, the disconnection in both phases is symmetrical, and 14 sections are completely short-circuited. The last two sections remain in circuit since when two locomotives are connected together it may be necessary, owing for instance to unequally worn tyres, to run their motors at different speeds to maintain the same speed on the track. Although the cutting-in, or out, of the resistances is normally effected by steps, an alternative method is provided for by which the breaking of the motor circuit, the inversion of the pole and cascade switches and the re-insertion of the motors may be carried out almost instantaneously. This arrangement is provided so that the changes may be made when the locomotive is running, without it losing too much of its speed. The braking of the locomotive on gradients is electrical with recuperation of energy taking place automatically through the over-synchronous running of the motors.

The motors are illustrated in Figs. 14, 16, 17 and 19. Each has a maximum capacity of 1,450 h.p., at 250 r.p.m., which corresponds to a locomotive speed of 75 km. per hour. The weight of each motor, including the crank, is 14 metric tons. The stator shell and the rotor spider are steel castings, the former being in one piece and the latter in two, bolted together. The main bearings are ring oiled and are carried on brackets bolted to the stator frame, as shown in Fig. 15. The boss of each rotor spider carries a cast-steel barrel, on which there are four slip-rings. This is illustrated in Fig. 17, but is perhaps best shown in the cross-section of the locomotive given in Fig. 6. There is a brush-rocker corresponding with each slip-ring, each rocker carrying six brush-holders. The brushes are confined to the upper part of the slip-rings, as shown in Fig. 15. The rotor has a 2·3 mm. air gap.

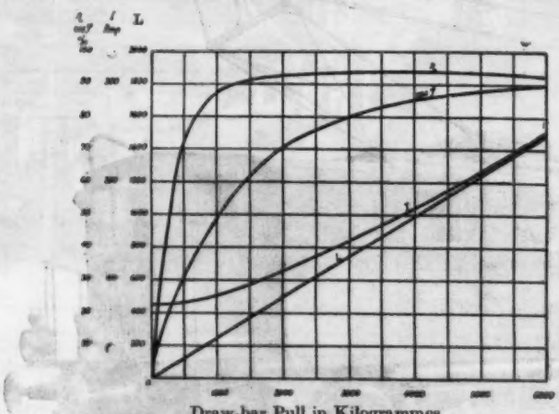
The rotor of each motor has similar windings, each having 96 half-open slots which lie at an angle to the axis of the shaft. Each slot contains 16 strip-copper connections. Diagrammatically the stators have similar windings in parallel connection, but they differ from each other by the division of the winding connections among the slots. This is owing to the fact that the primary stator has in cascade connection to carry the magnetising current of the secondary motor, and consequently must have a larger leader section than the secondary stator. Each stator has 72 slots containing 12 leads in layers one above the other. The slots of the secondary stator are half-open, those of the primary are entirely open. To allow the number of poles to be changed, the winding of each stator is divided into 18 circuits giving 30 end connections. These are carried to the contacts of the pole-changing switch. Micanite is used throughout for slot insulation, and the windings are secured by fibre wedges. The rotor coil ends are held by steel wire bands. As already stated, the motors are provided with forced draught cooling. They have ventilation openings and ducts in the shells, and the passages are so placed that the coil ends are properly cooled. The motors exceeded their efficiency and power factor guarantees at all service speeds. Fig. 21, above, gives characteristic curves of the primary motor in parallel connection at 75 km. per hour, and Fig. 22 curves for the set in cascade connection at 37·5 km. per hour. The curves relate to a frequency of 15 periods and a pressure of 3,000 volts.

The pole-changing switch, which is fixed above the motor, as shown in Fig. 17, is of the drum type. The ends of the stator windings are connected to a series of contact fingers, and the segments on the drum give the various necessary connections. The switch also looks after the changing-over of the primary stator from star to star-delta and the changing-over of the secondary stator from three to six-phase. The various connections can be traced from Fig. 9. The cascade switch is of similar construction to the pole-changing switch. Its contact fingers are connected to the supply and the stator windings, slip rings and resistance. Both the pole-changing and cascade switches are operated by a pneumatic relay from either of the drivers' compartments. The starting resistance is built up of grid resistances in 42 boxes. The resistance is non-inductive and is air cooled by two fans, but is of sufficient capacity to operate with one fan out of action. The resistance controller has three contact drums, each provided with a magnetic blow-out. Each barrel is divided into symmetrical halves, and each half connects to a division of the starting resistance. To obtain the largest possible number of working positions with the smallest possible number of contacts and fingers, an unsymmetrical subdivision has been made so that the resistance in circuit differs for all the 16 controller steps. The controller is operated by a pneumatic relay from either driving compartment, the relay being arranged either to switch by steps or to switch in the whole resistance instantaneously. The first five steps can also be switched out instantaneously. The controller may also be operated by hand.

In the normal operation of the locomotive the main switch is closed, and the breaking of the motor circuit on starting, stopping, &c., is carried out on the motor switch. This switch is illustrated in Fig. 18. It is provided with a relay operated automatically from the resistance controller which opens or closes the switch in terms of the movement of the controller. The switch is fitted with stepped resistances which prevent current rushes in the motors and also protect the switch itself. The air valves in the driver's compartment for operating the current collector, the main oil switch and the controllers are mechanically interlocked to prevent them being operated in the wrong order. The handle for the middle valves which control the cascade and pole-changing switches is removable, and is taken by the driver when he changes from one compartment to the other. When the handle is turned to the off position and removed the air valves are locked in the off position. The handle of the current collector valve can be removed after lowering the collector, and may then be used for unlocking the door of the high-tension compartment. Interlocks are also provided between the resistance controller and the operating valve of the main oil switch, between the direction of travel reversing switch and the pole-changing and cascade controllers, and also between the motor switch and the two latter controllers.

In the official trials of the locomotives by the Italian State Railways, the first tests were made to determine motor output. The trial consisted in starting a locomotive and running up to a speed of 75 km. (46 miles) an hour on a gradient of 1 in 62·5 with a useful load of 270 tons. Draw-bar pull was measured by a dynamometer car. The specification required that a speed of 75 km. per hour should be reached in not more than 500 seconds, corresponding to an average acceleration of 0·042 m. (0·138 ft.) per second per second. The actual time required on the trials was 322 seconds, corresponding to an acceleration of 0·065 m. (0·213 ft.) per second per second. The guaranteed draw-bar pull was realised at all speeds, the highest pull of 12,000 kg. (26,000 lb.) being obtained at between 50 km. and 75 km. (31 miles and 46 miles) per hour. Tests followed to ascertain that the starting resistances were correctly connected and proportioned. For these trials a train of wagons weighing 350 tons was started 22 times on a gradient of 1 in 33·3 and run up to 37·5 km. (23 miles) an hour. The various starts were timed at 3 minutes intervals. The rise in temperature of the resistances after this programme could not be directly measured, but the temperature of the air current between two resistance boxes showed a maximum of only 52 deg. C.

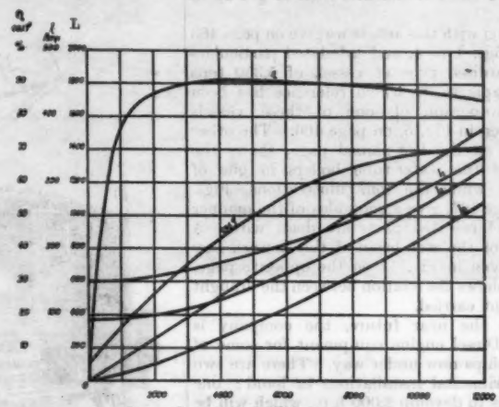
Duration tests were carried out running six double journeys between Genoa and Savana in 22 hours. The total distance travelled was 516 km. (830 miles) and a load of 407 tons (exclusive of the weight of the



Draw-bar Pull in Kilogrammes.

Fig. 21. Characteristic Curves of Primary Motor, 8 Pole Connection in Parallel, 75 Kilometres per Hour.

η = Efficiency, I = Main Current, L = Horse-Power.



Draw-bar Pull in Kilogrammes.

Fig. 22. Characteristic Curves of Motor Set, 8 Pole Cascade Connection, 37·5 Kilometres Per Hour.

η = Efficiency, I_1 = Primary Current, I_2 = Secondary Current, I_3 = Tertiary Current, L = Horse-Power.

locomotive) was hauled. Journeys were made at speeds of 37·5 km., 50 km. and 75 km. (23 miles, 31 miles and 46 miles) per hour. In some cases intermediate stations were stopped at. In others a through run was made. After every journey the temperature of the stator winding of the primary motor was taken. The maximum reading found was 60 deg. C., which was after a trip stopping at all stations. This figure was considerably reduced by a fall in air temperature, and the last measurement showed only 28 deg. C. Seven runs were also made in 20 hours with a load of 180 tons, and at speeds up to 100 km. (62 miles) per hour. The total distance run was 532 km. (850 miles). The maximum temperature of the stator winding found during this test was 30 deg. C. Three other tests were made with two locomotives on the Lecco and Monza line, at speeds of 50 km., 75 km. and 100 km. (31 miles, 46 miles and 62 miles) an hour. The useful load hauled was 694 tons on 70 axles, 668 tons on 90 axles, and 367 tons on 50 axles, and the gradient was 1 in 83·5 in the case of the first speeds and 1 in 143 in that of 100 km. per hour.

The results of all these tests were quite satisfactory, as were also those of a series of trials which were purposely made severe by running only one cooling fan. A train of 322 tons was started under these conditions and run up to 50 km. per hour on a gradient of 1 in 83·5, and the journey was continued at 50 km. per hour for 17 km. Tests then followed with a train of 367 tons run up to 75 km. (46 miles) an hour, with the second cascade switch disconnected. This was specially severe on the starting resistances, but no signs of overheating were found. The results of the whole of the trials showed that the locomotives were a very satisfactory job, and one which evidently had not suffered in quality from being carried out in war time.

METAL PRICE DIAGRAM.

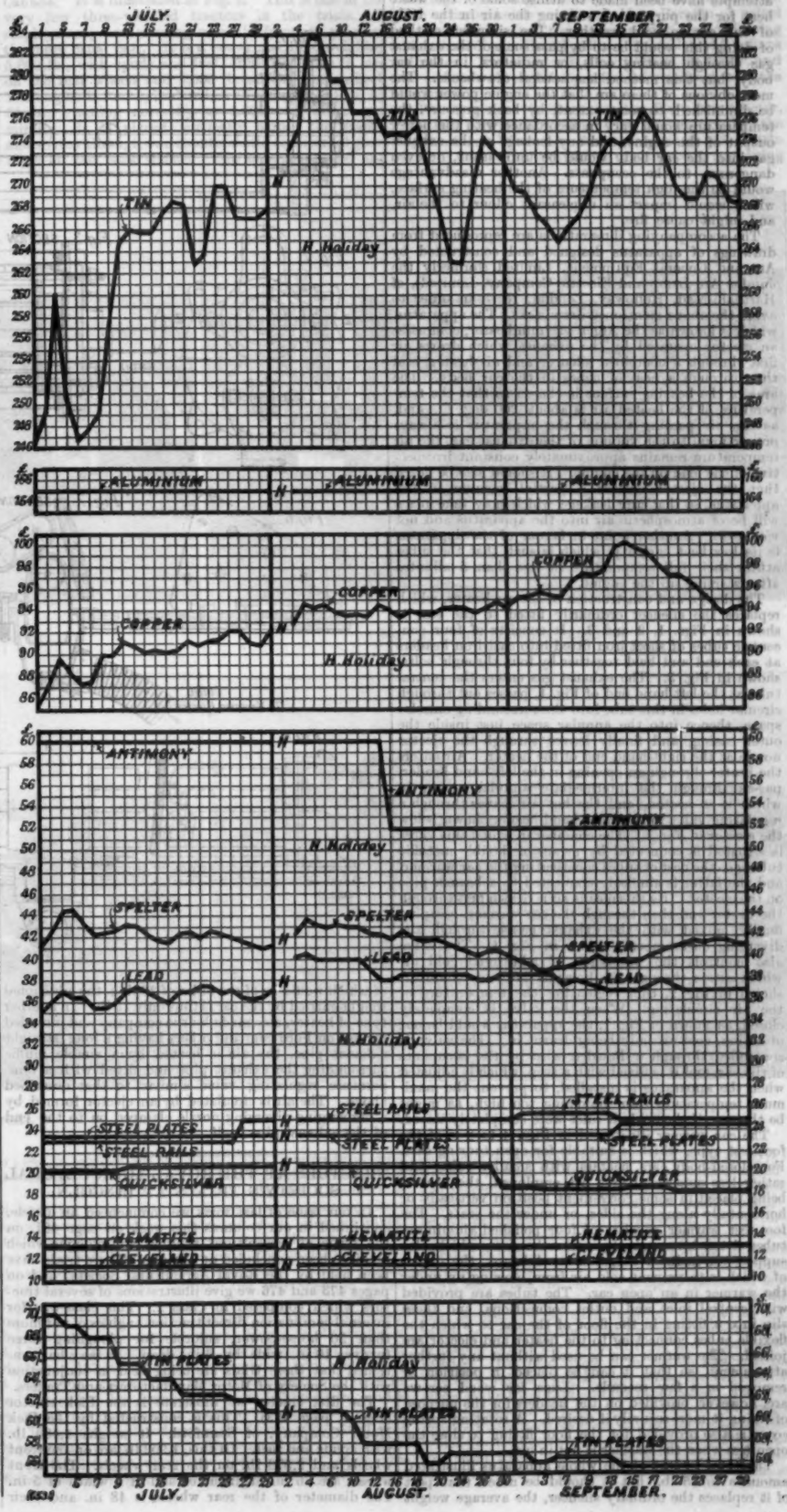
Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1l. each, except in the case of the diagram relating to tin-plates, where they represent 1s. each.

Freight Rates for Aerial Transport.—We are informed that the freight rates for goods carried on the Handley-Page air services between London and Paris and London and Brussels, and *vice versa*, have been further reduced, and that, from London, the charge for loads up to 100 lb. is now 1s. 3d. per lb., with a minimum charge of 2s. Loads heavier than 100 lb. are charged at the rate of 1s. per pound. The rates for goods carried to London from the Continent are 7 francs per kilogramme up to 50 kilogrammes, and 6 francs per kilogramme for heavier loads, with a minimum charge of 5 francs. The new rates came into operation on October 1 last.

Personal.—We are informed that an amalgamation has been effected between Messrs. W. H. Spencer and Co., engineers and boiler makers, Hitchin, Herts., and the Bonecourt Waste Heat Boiler Company, Limited, Parliament Mansions, Victoria-street, London, S.W. 1, the two businesses having been transferred to a new company entitled Spencer-Bonecourt, Limited. Mr. Charles William Catt will act as chairman of the new company and Mr. P. St. G. Kirke, who has been appointed consulting engineer, will supervise the design of boilers under the Bonecourt and Kirke patents. Mr. A. L. H. Spencer and Mr. P. A. Sharman, who are managing directors of the new company, will continue to manage the works at Hitchin as heretofore. The head office of the company will be at Parliament Mansions.—Messrs. Hall and Pickles, Limited, Manchester and Sheffield, iron and steel stockholders, and Hydra tool steel manufacturers, have removed their London office to Iddesleigh House, Caxton-street, Westminster, London, S.W.—The Brightside Foundry and Engineering Company, Limited, of Sheffield, state that owing to the expansion of their business they have been compelled to take over larger premises in Liverpool, and communications from October 2 have to be forwarded to their new address, 242, Upper Parliament-street, Liverpool. Their new telephone number is 3817 Royal, and the telegraphic address "Brifoueng," Liverpool.—Mr. George Anderson, A.M.I.N.A., intimates that he has severed his connection with Messrs. Fleming and Ferguson, Limited, after sixteen years' representation of that firm's interests in London, and that he intends to carry on business at No. 9, Fenchurch-avenue, as a dredging plant specialist.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



MOTOR-CAR WARMING APPARATUS.

Such a large proportion of the heat in the fuel supplied to a petrol motor-car engine is lost in the exhaust gases that it is not surprising that several attempts have been made to utilise some of the waste heat for the purpose of warming the air in the body of the car in cold weather. The simplest method of doing this would be to by-pass some of the exhaust gas through heating coils, or radiators, in the car body, but this method has several drawbacks. The most obvious of these are that the engine power would be diminished, to some extent, by back pressure, the temperature would vary in accordance with the power output of the engine, and any leakage of the exhaust gas into the car body would be unpleasant, or even dangerous, to the occupants. Another disadvantage would be the high temperature of the heating surface, which would impart an unpleasant odour to the air, and might cause fire.

The accompanying illustrations are reproduced from drawings of apparatus designed and constructed by Arc and General Equipment, Limited (formerly the Jandus Arc Lamp and Electric Company, Limited), of Hartham-road, Holloway, London, N. 7, in order to avoid the above-mentioned drawbacks. The apparatus, which is known as the Argen vacuum heater, comprises an ejector operated by the exhaust, which draws air first through a combined silencer and air heater, and then through a nest of tubes in the car body. The area of the heating surface is chosen so that the temperature of the heated air is about 200 deg. F., and, as the air passing through the apparatus is always proportional to the volume of the exhaust gas, the air temperature remains approximately constant irrespective of the load on the engine. It should also be noted that the ejector creates a partial vacuum in the apparatus, so that any leakage which may take place will be of atmospheric air into the apparatus and not *vice versa*. Another point in favour of the apparatus is its low heat capacity, which is such that the tubes attain their full temperature in less than 5 minutes after starting up the engine.

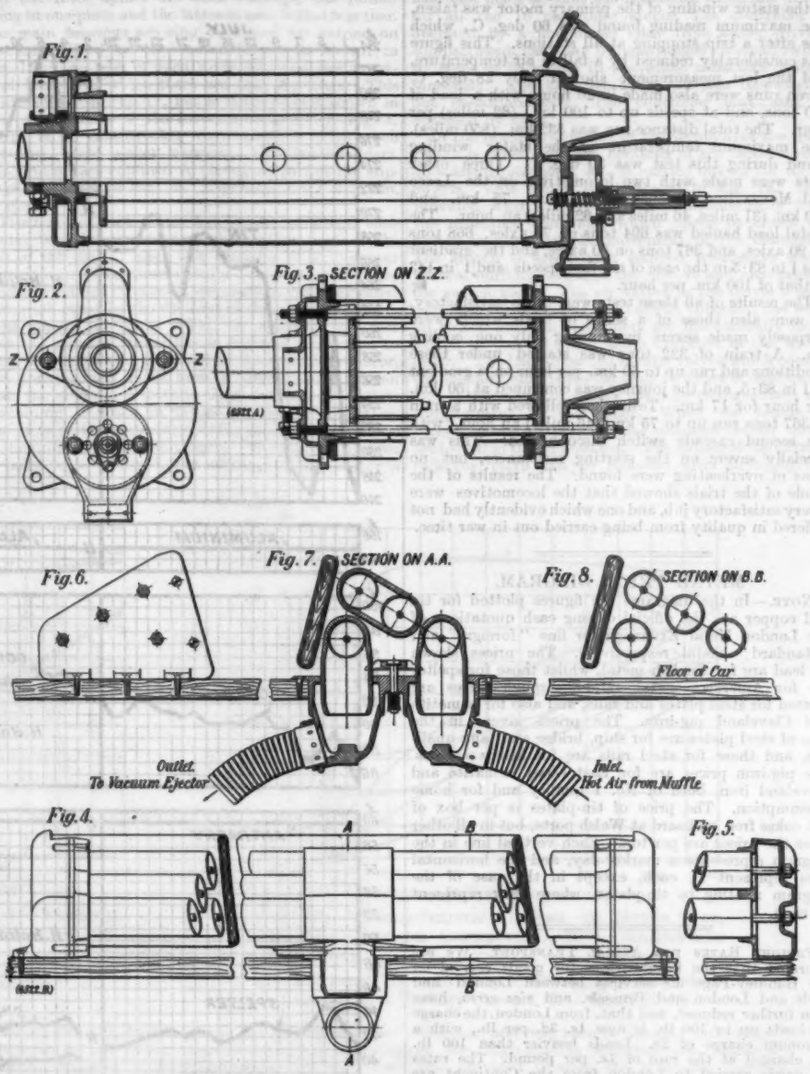
The design and construction of the air heater, which replaces the silencer ordinarily fitted to the car, is shown in Figs. 1, 2 and 3. It consists of four concentric tubes of sheet iron fitted into cast-iron headers at each end and held together by four through bolts, shown in Fig. 3. The exhaust gas enters the central tube at the left-hand end of Fig. 1, passes out through circular holes in this tube into the surrounding annular space, thence into the annular space just inside the outer casing, and finally leaves through the ejector nozzle at the right-hand end of the heater. Air enters the heater through an opening in the left-hand header, passes through the intermediate annular space, in which it is heated, and the hot air leaves through a regulating valve in the right-hand header shown below the ejector in Fig. 1. The chamber in which this valve is situated is connected by means of flexible metallic tubing to the nest of tubes constituting the car warmer, and the latter is similarly connected to a branch pipe on the ejector. By this means air is drawn first through the heater and then through the car warmer, escaping finally, mixed with the exhaust gases, through the diverging outlet nozzle shown in Fig. 1. The valve also controls the admission of additional cold air which enters through the holes in the valve chamber, shown in Fig. 2, thus regulating the temperature of the air circulating. When the valve is completely closed, as shown in Fig. 1, the apparatus would be out of action, cold air only being drawn in. The valve is controlled through a Bowden wire by the occupants of the car, and it is fitted with a stop, which is adjusted when the apparatus is installed, to prevent the maximum temperature from becoming too high, as might be the case if the cold-air inlet were completely closed.

The car warmer illustrated in Figs. 4 to 8 is of the foot-rest type, which is suitable for open touring cars. For closed-body cars, heaters with smaller tubes and rather less superficial area are employed, the heaters being placed in some convenient position vertically or horizontally along the sides, or under the seats. The foot-rest warmer consists of four polished aluminium tubes fitted into cast aluminium headers, which also support an inclined carpet-covered board, the object of which is to prevent cold air from blowing up under the warmer in an open car. The tubes are provided with central inlet and outlet connections, and these slip into a fitting in the floor of the car to which the flexible tubes connecting to the heater and ejector are joined. The warmer can be used without any further attachment, so that it can be placed in position or removed in a few seconds. Lugs for wood screws are, however, provided on the headers for the purpose of fixing it more securely if desired. A rotating spring cover is also provided for the floor fitting to close the openings when the warmer is not in use.

The total weight of the whole apparatus illustrated amounts to 35 lb., but it should be noted that part of it replaces the ordinary silencer, the average weight of which would be of the order of 20 lb.; the additional weight carried by the car is thus only 15 lb. In another type of heater, also made by the company and intended for use on Ford cars and others having a long straight exhaust pipe, the air is heated by a simple muffle surrounding the exhaust pipe and fitted with a temperature regulating valve similar to that described above. The air is circulated by an ejector formed by a converging-diverging nozzle clamped on to the end of the exhaust pipe itself.

MOTOR-CAR WARMING APPARATUS.

CONSTRUCTED BY THE ARC AND GENERAL EQUIPMENT, LTD., ENGINEERS, LONDON.



TRACTORS AT THE ROYAL AGRICULTURAL SOCIETY'S TRIALS AT LINCOLN.

In our issue of last week we commenced an article, continued in our columns this week on page 481, on the trials of agricultural tractors and ploughs which has just been concluded at Lincoln. These trials have been held by the Royal Agricultural Society, and on pages 473 and 476 we give illustrations of several tractors which competed in Class 2. This class was for internal combustion direct traction engines of not more than 30 horse-power, suitable for ploughing three furrows 10 in. wide by 6 in. deep. It may be mentioned that these trials are being held in conjunction with the Society of Motor Manufacturers and Traders.

The first tractor we illustrate is the Pick tractor (Fig. 1, page 473). This is constructed by the Pick Motor Company, of Stamford. It weighs 4,480 lb. with spuds and fuel. Of this, 1,902 lb. are on the front wheels and 2,576 lb. on the rear wheels. The front wheels are 36 in. in diameter and of a width of 5 in. The diameter of the rear wheels is 48 in. and their width 12 in. The machine has a four-cylinder engine, with cylinders 4¼ in. in diameter and 5 in. stroke, running usually at 800 revolutions per minute. The horse-power is rated at 21. There are three speeds forward and one in reverse. The final drive is by worm. The belt pulley provided is 14 in. in diameter and of 7 in. face, running at 800 revolutions per minute. The tanks have a capacity of 8 gallons of paraffin and 5 gallons of water.

The Martin tractor shown in Fig. 2 is by Messrs. Martin's Cultivator Company, Limited, Lincolnshire Ironworks, Stamford. It weighs 5,824 lb. with spuds and fuel, and carries 15 gallons of paraffin, 3 of petrol and 9 of water. It has an engine with four cylinders 4¼ in. diameter and 5½ in. stroke, running at 900 revolutions per minute, and rated at 23·2 h.p. It also has three speeds forward and one reverse, the final drive being by pinions and gear-rings. The wheels are 33 in. and 51 in. in diameter, and 6 in. and 10 in. wide respectively. The belt pulley is 18 in. by 6½ in. Two brakes are provided, namely, internal expanding and shoe, acting on the countershaft and rear wheels. This machine is one of the larger types of tractors in this class. Its frame is of channel steel. The engine is placed longitudinally and drives a gear-box placed across the machine, by means of bevels. From this the drive is taken to a cross-shaft embodying the differential. A winding drum on the axle is driven by a pinion which slides in and out of gear. The front axle is built up of flat bars, one upper and one lower being straight, and a third bent and riveted between them to form a lattice.

The "Dungey" tractor shown by Messrs. W. Weeks

and Son, Perseverance Works, Maidstone, is a somewhat lighter machine. It is illustrated in Fig. 3 and weighs 3,920 lb. with spuds and fuel, carrying 5 gallons of paraffin and 1 gallon of petrol. It is rated at 24·2 h.p., having an engine with four cylinders, 4¼ in. by 5½ in., running at 900 revolutions per minute. The final drive is by pinion and gear-ring. The wheels are 30 in. and 40 in. in diameter by 5 in. and 10 in. in width respectively. The load on the front wheels is 1,400 lb., and on the back 2,520 lb. The belt pulley is 8 in. by 6 in. The engine is placed longitudinally. There are three speeds and one in reverse obtained with a gear-box combined with the engine. From this a cross-shaft embodying the differential is driven by bevels. The drive to the wheels is cased in. The engine and gear-box unit is mounted on a three-point suspension. The front axle slides in horn-blocks instead of being with renewable liners. The cylinder heads are detachable. Lubrication is by splash. Paraffin is used as fuel, 20 gallons being carried. Petrol is used for starting. The water carried is 3 gallons.

The Chase tractor is entered by the Chase Tractors Corporation, Limited, 28, Atlantic-avenue, Toronto, Canada. It is illustrated in Fig. 5. This is one of the very few three-wheeled tractors in the trials. It employs only one steering wheel in front, in place of the more usual pair. It is a heavy machine, weighing 5,600 lb., with spuds and fuel, of which 3,550 lb. are on the rear wheels and 2,050 lb. on the front wheel. The engine is four-cylindered, with cylinders 4¼ in. by 5½ in., running normally at 1,000 revolutions per minute. It is placed vertically across the frame, and drives through two countershafts to internal gear-rings on the back wheels. Two speeds forward and back wheels. The back axle is mounted in eccentric bushes, so that the wear in the final drive may be taken up. The front axle consists of an angle iron with a flat bar riveted to it. The latter is bent up at the ends to form, with the angle iron, the jaws for the steering pivots. The wheels are fitted with Skefko bearings. The engine is fitted with forced lubrication. The cylinder heads are detachable. Paraffin or petrol can be used for fuel, the tank capacity provided being 18 gallons of paraffin, 2½ gallons of petrol, and 7 gallons of water. The radiator is placed across the frame, and air is drawn through it by a fan driven direct from the engine.

Fig. 7, page 476, illustrates the Hart-Parr tractor, another American model. This is entered by the Agricultural Wholesale Society, Limited, 46, Mark-lane, E.C. 3. This machine is of a special type, having

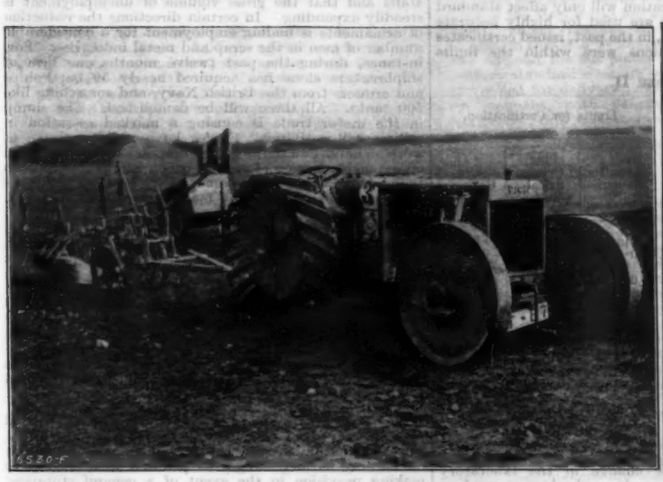


FIG. 1. THE PICK TRACTOR.

FIG. 2. THE MARTIN TRACTOR.

FIG. 3. THE DUNGEY TRACTOR.

FIG. 4. THE BRITISH WALLIS TRACTOR.

fitted with the more usual radius rods. The main frame is of channel section, and the whole machine is uncommonly compact.

The British Wallis, illustrated in Fig. 4, is entered by the Ancona Motor Company, 78, Brompton-road, S.W. 3. This machine weighs only 3,360 lb., and is one of the lightest entered in the class. The engine has four 4¼ in. by 5½ in. cylinders, and is rated at 22·9 h.p., running at 850 revolutions per minute. The wheels are 30 in. and 48 in. in diameter by 8 in. and 12 in. wide respectively. This machine is of the type in which the engine and gear-box are in one unit with the back axle, no separate frame being employed. A U-shaped pressing of steel plate forms the bottom of the crank-case and gear-box, and practically constitutes the main frame of the machine. This appears to be an excellent form of construction, and it combines the advantages of unit construction without the complications of separate framing, while the stresses are taken by forged material. There are two speeds forward and one in reverse. The cylinders are fitted one in reverse are provided. The framing is of steel channel. The single front wheel simplifies construction to a considerable extent and cuts out a number of moving parts. Steering is by a worm gearing direct with a worm wheel on the top of the steering pivot. This arrangement can be seen in our illustration. The front wheel has a concave rim. The single front wheel arrangement worked out as in this example would appear to promise success and cheapness in maintenance.

The Parrett tractor, entered by the Agri-Tractor Contract Company, Royston, Herts, is illustrated in Fig. 6. It weighs 5,515 lb., with spuds and fuel. Of this, 4,137 lb. are on the rear wheels, which are 60 in. by 10 in. width. The front wheels are 46 in. by 4 in. The engine has four cylinders, 4¼ in. by 5½ in., and is rated at 25·8 h.p. at 1,000 revolutions per minute. The engine is placed across the frame, which is of deep sectional channel steel. The engine drives a countershaft direct in all of the three speeds. From this countershaft the drive is by pinion and gear-ring on the an engine with two horizontal cylinders, 6¼ in. by 7 in. stroke. It runs at the comparatively slow speed of 750 revolutions per minute, and is rated at 28·8 h.p. The design enables the big ends and main bearings to be got at without getting underneath. The cylinder heads are detachable, the valves being fitted in them. Paraffin is used as fuel, the capacity of the tank being 23 gallons. The fuel charge is heated when running light, but, when the throttle is open, the heater is cut out and the fuel sprayed in direct. Mechanical lubrication is provided to each bearing, whence the oil is taken to lubricate the final drive gears. The engine is placed across the frame, driving a countershaft by gearing. The final drive is by pinion and gear-ring. The back axle is straight, right across the machine, one wheel being fixed to it and the other loose. The frame is a combination of forged and cast steel. The engine, gear-box and back axle are carried on a casting, from which two channels extend forward to carry the radiator and front axle. The machine weighs 5,712 lb., being one of the heavier designs. The wheels are 28 in. and

52 in. in diameter. One band brake acts on the differential. The belt pulley is 14 in. by 8 in., on the crankshaft.

The G.-O. tractor, shown by Messrs. Noyes, Stockwell and Co., Limited, Lennox House, Norfolk-street, Strand, W.C. 2, is shown in Fig. 8, page 476. In this machine the engine, which has four 4¼ in. by 5½ in. cylinders, is placed longitudinally. It runs at 955 revolutions per minute, and is rated at 28·8 h.p. Behind the engine is a cross-shaft, driven by friction gearing from a wheel on the crank-shaft. There are two friction discs, either of which can be forced against the wheel on the crank-shaft, giving respectively the speed ahead and reverse. The wheel on the crank-shaft can be moved by the speed control lever, thus providing a variable speed ratio. Six notches are arranged for the control lever, so that six speeds are obtainable forward or reverse. The friction discs are forced against the driving wheel by a lever through an adjustable spring, and a quadrant. Two notches are provided for this lever, so that two pressures can be secured without other adjustment. The cross-shaft drives a 2 in. shaft by spur gears, the drive from the latter shaft to the differential being by other spur gears. The frame is of channel steel. The machine weighs 4,200 lb. The wheels are 30 in. by 5 in. and 46 in. by 10 in. The belt pulley, which is 10 in. by 6 in., is on the cross-shaft and, therefore, also has six speeds. Twenty gallons of paraffin are carried and 8 of petrol.

The machine shown ploughing in Fig. 9 is the Twin City model entered by Messrs. Fairbanks, Morse and Co., Limited, 87, Southwark-street, S.E. 1. The frame of this machine is entirely cast, but does not incorporate the crank-case. The gear-box and differential casing form one casting to which extensions are bolted on to form the back axle. A substantial casting of trough section is bolted to the front and extends to the front axle. The engine is a separate unit, standing on the casting as a base. It has four cylinders, 4½ in. by 6 in., and at 1,000 revolutions per minute is rated at 28·1 h.p. There are two speeds forward and one in reverse. The machine weighs 4,500 lb., of which 3,250 lb. are on the rear wheels, which are 50 in. by 12 in. The front wheels are 34 in. by 5½ in. The pulley is 16 in. by 6 in., and runs at 650 revolutions per minute.

Our last illustration, Fig. 10, shows the Cletrac (Cleveland), entered by Messrs. H. G. Burford and Co., Limited, 16, Regent-street, S.W. 1. This is a caterpillar type machine, with the engine mounted longitudinally in front, driving through a reverse gear to bevel gears, which drive a cross-shaft. From this the rear sprockets are driven through internal gear-rings. The engine has four cylinders, 4 in. in diameter by 5½ in. stroke. It is rated at 22·8 h.p. at 1,000 revolutions per minute. The machine weighs 3,472 lb. with fuel, the paraffin carried amounting to 11 gallons, with half a gallon of petrol for starting. The sprocket centres are 50 in. apart and the length of tread is 48 in. The pitch of the links is 4½ in. and their width 8 in. Steering is effected by differential gear arranged so that either track can be driven two and a-half times as fast as the other. The front sprockets and track rollers are carried on side frames pivoting separately on the centre of the back sprocket. A cross spring in front rests on these side frames and carries the main frame at its centre. The tracks can, therefore, move independently vertically at the front end. The track plates and links are in one piece of malleable iron. In use, as shown in Fig. 10, both the tracks run on the unploughed ground, which, it is claimed, greatly lessens the resistance, with a consequent reduction of fuel. A rod projects ahead of the tractor, with a roller running in the last furrow, for guiding the machine. The belt pulley is 8 in. in diameter by 6 in. face, and runs at 1,000 revolutions per minute.

SIZES OF THE N.P.L. END STANDARDS IN ENGLISH UNITS.

The National Physical Laboratory have issued the following notice respecting a change which has been made in the accepted sizes of the laboratory end standards in English units :—

As a result of recent determinations of the absolute sizes of the laboratory standard end gauges in inch units, it has been found necessary to make a change in the sizes which have been accepted for them up to the present. This determination has been unfortunately delayed by the war. The alteration in the sizes is proportional to the length of the gauges, and is at the rate of minus 12 parts in 1,000,000. For example, the accepted sizes for the 1-in. and 12-in. standard gauges have been reduced by 0·000012 in. and 0·00014 in. respectively. The laboratory end standards in metric units are not subject to this change.

On and after October 15, 1920, all gauges submitted to the laboratory for measurement will be tested on the new basis. Firms who are in possession of reference gauges in inch units which have been tested at the laboratory prior to October 15, 1920, should modify the values which were given by the laboratory in order to bring them in line with the new values which will be taken for the standard gauges. For example, if the length of a 12-in. end gauge were given as 12·00006 in. the revised length would be 11·99992 in.

Table I gives the amount of change to be made for a number of lengths. Intermediate sizes can be found by proportion.

Table I.

Length. (In.)	Alteration to be made in Size (In.).
1	− 0·00001
2	− 0·00002
3	− 0·00004
4	− 0·00005
5	− 0·00006
6	− 0·00007
7	− 0·00008
8	− 0·00010
9	− 0·00011
10	− 0·00012
11	− 0·00013
12	− 0·00014
24	− 0·00029
36	− 0·00043

It is clear that this alteration will only affect standard or reference gauges which are used for highly accurate work. The laboratory has, in the past, issued certificates for gauges whose dimensions were within the limits given in Table II.

Table II.

Size of Gauge.	Limits for Certification. Length Gauges.	Plug Cylindrical Gauges.	Slip Gauges.
	in.	in.	in.
Up to and including 1 in.	±0·0001	±0·00005	+0·00002 −0·00001
From 1 in. up to and including 2 in.	±0·0001	±0·0001	+0·00002 −0·00001
From 2 in. up to and including 3 in.	±0·0001	±0·00015	+0·00003 −0·00002
From 3 in. up to and including 4 in.	±0·0001	±0·00015	+0·00004 −0·00003
From 4 in. up to and including 6 in.	±0·0001	±0·0002	—
From 6 in. up to and including 12 in.	±0·0001	±0·0003	—
From 12 in. up to and including 18 in.	±0·00015	±0·0004	—
From 18 in. up to and including 24 in.	±0·0002	—	—

It is realised that this change in the laboratory standards will affect gauge makers who have a stock of finished gauges made (on the basis of the original values of the standards) to suit the above limits of certification. On the new basis for the standards it is possible that such gauges would no longer fall within the limits. To meet such cases, the laboratory is prepared, for a period of twelve months, *i.e.*, until October 15, 1921, to extend the limits for certification, as given in Table II, in order to cover the change in the sizes of the standards.

The extended limits are given in Table III.

Table III.

Size of Gauge.	Limits for Certification for Period October 15, 1920, to October 15, 1921. Length Gauges.	Plug Cylindrical Gauges.	Slip Gauges.
	in.	in.	in.
Up to and including 1 in.	+0·00010 −0·00011	+0·00005 −0·00006	+0·00002 −0·00002
From 1 in. up to and including 2 in.	+0·00010 −0·00012	+0·00010 −0·00012	+0·00002 −0·00003
From 2 in. up to and including 3 in.	+0·00010 −0·00014	+0·00015 −0·00019	+0·00003 −0·00006
From 3 in. up to and including 4 in.	+0·00010 −0·00015	+0·00015 −0·00020	+0·00004 −0·00008
From 4 in. up to and including 5 in.	+0·00010 −0·00016	+0·00020 −0·00026	—
From 5 in. up to and including 6 in.	+0·00010 −0·00017	+0·00020 −0·00027	—
From 6 in. up to and including 7 in.	+0·00010 −0·00018	+0·00030 −0·00038	—
From 7 in. up to and including 8 in.	+0·00010 −0·00020	+0·00030 −0·00040	—
From 8 in. up to and including 9 in.	+0·00010 −0·00021	+0·00030 −0·00041	—
From 9 in. up to and including 10 in.	+0·00010 −0·00022	+0·00030 −0·00042	—
From 10 in. up to and including 11 in.	+0·00010 −0·00023	+0·00030 −0·00043	—
From 11 in. up to and including 12 in.	+0·00010 −0·00024	+0·00030 −0·00044	—
18 in.	+0·00015 −0·00037	+0·00040 −0·00062	—
24 in.	+0·00020 −0·00049	—	—

Although the limits for certification will be as given in Table III for the period October 15, 1920, to October 15, 1921, the actual sizes in inches of all gauges will, on and after October 15, 1920, be given in accordance with the new values for the standard gauges. After October 15, 1921, the limits for certification will be as given in Table II.

North Sea Train Ferry.—The invitation extended by the Federation of British Industries to Swedish representatives to visit England for the purpose of discussing further action with regard to the establishment of a steam ferry service between Great Britain and Sweden has been accepted, and the delegates reached England on September 20.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The development in the coal trade position has enabled the continuance of production on existing contracts, but is not of much assistance in the matter of attracting new business. The point has been reached when orders are beginning to be badly wanted in some of the heavy engineering departments. Evidence is not wanting from recent communications that big trade is waiting to be done as soon as makers can quote firm prices and assure regular delivery, but until then many buyers on the Continent and in the Colonies are content to postpone developments and eke out on essential requirements for renewals and repairs. Difficulty is experienced in keeping some of the heavy sections fully employed. One firm alone has given a week's notice to 1,000 employees, and although this is rather an isolated case, it is nevertheless true that hundreds of firms are slowly but gradually reducing staffs and that the gross volume of unemployment is steadily expanding. In certain directions the reduction of armaments is finding employment for a considerable number of men in the scrap and metal industries. For, instance, during the past twelve months one firm of shipbreakers alone has acquired nearly 50 battleships and cruisers from the British Navy, and something like 500 tanks. All these will be demolished. The slump in the motor trade is causing a marked cessation in rolling mill activities. Forges have a fair volume of work on hand, and the large foundries are steadily engaged on extensive arrears of orders, which will probably keep them busy up to Christmas. Moderate order books are reported to be held by makers of railway material, tramway points and crossings, and vehicles, though here again there is evidence that British Corporations are buying in cheaper markets, not only on account of price considerations, but because home firms cannot guarantee delivery. The increasing arrivals of foreign billets is slightly affecting local production. Belgian castings are also coming into Sheffield, but the arrival of these is welcomed by engineering firms, who, so far as shipbuilding requirements are concerned, are months behindhand with orders. In raw and semi-finished materials, the scarcity of foundry iron is the predominant feature. A general easing off is reported in the demand for forge qualities.

South Yorkshire Coal Trade.—Output at the local pits has improved considerably during the past week. The explanation is said to be that miners are intent on earning as large wages as possible with a view to making provision in the event of a general stoppage. Renewed efforts are being made to increase much-depleted stocks at iron and steel works, at gas companies, and at public utility concerns. The demand from London and the South generally for increased supplies of house coal is persistent. Locally the position is easier, though merchants have their work fully cut out to keep pace with requirements. Quotations :—Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

The British Industries Fair (Birmingham), 1921.—The Birmingham section is again being organised by a Joint Council of the Birmingham Corporation and the Chamber of Commerce, and, at the time of writing, the space for next year's fair, to be held at Castle Bromwich from February 21 to March 4, is being booked very rapidly. The fair affords an opportunity for meeting the buyers of the world, and enables such buyers to see a splendid display of the classes of goods which they wish to deal in. The display is being held as an integral part of the London and Glasgow Fairs, the latter of which will, however, overlap London and Birmingham by a week. Full information can be obtained on application to the General Manager, British Industries Fair (Birmingham), 1921, Chamber of Commerce Building, 95, New-street, Birmingham.

Standardisation of Optical Instruments.—The report of the committee, appointed by the Department of Scientific and Industrial Research, to standardise the elements of optical instruments, has now been published by H.M. Stationery Office, the issue price being 1*s.* It is interesting to note that, after a careful consideration of all the factors involved, it was decided to base the new standards on the British inch and not to change over to the metric system. The only exception is that for small constructional screws the British Association threads have been adopted, but for fine-motion screws the inch basis is retained. With respect to tubing, inquiry showed that there were literally thousands of different sizes of brass tubing in use of less than 6 in. in diameter. There was obviously a great chance for economies here, and the committee have accordingly listed a number of sizes between ¼-in. and 3-in. bore, which they think will meet all ordinary requirements. A list of standard screw threads for this range of tubing has also been compiled. In this connection the committee note that if a tube be screwed home against a square shoulder it will jam and not be liable to shake loose if the product of the diameter and number of threads per inch exceed 72. Thus, with a diameter of 3 in. and 30 threads per inch, the screw will jam, as the product of these two quantities is 90, whilst with 18 threads per inch and the same diameter the screw will work loose if exposed to vibration.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—What slight change is noticeable in the Cleveland pig-iron trade is for the better. Scarcity of qualities which have been so difficult to obtain for some time past, is hardly so acute. Supply of No. 1 and No. 3, however, is still inadequate to home needs, and consequently none is purchasable for abroad, makers adhering to their decision not to sell for export so long as home requirements cannot be fully met. Mottled and white are fairly plentiful, but producers are not prepared to make any price concessions for home use. Only limited quantities of silicious iron are on the market. For home consumption, No. 1 is 237*s.* 6*d.*, No. 3, and the inferior grades of Cleveland pig-iron, are 225*s.*, and silicious is 255*s.*; whilst for export, mottled and white are offered freely at 230*s.*, and what parcels of silicious come forward are promptly taken up at 277*s.* 6*d.*

Hematite Iron.—There is little new in the hematite branch. Pressure for delivery against contracts made is somewhat less insistent, and at the same time there is not much iron available. To home customers, No. 1 is 262*s.* 6*d.*, and mixed Nos. are 260*s.*; whilst, though several makers are now asking more, the recognised market quotations for shipment to France, Belgium and Italy still stand at 267*s.* 6*d.* for No. 1 and 265*s.* for mixed Nos. Odd sales of mixed Nos. to other destinations abroad are reported at 280*s.*

Foreign Ore.—Inquiries for foreign ore are once more heavy. Consumers are prepared to negotiate for delivery over the first half of next year, and renewal of extensive buying is confidently anticipated. Rubio, of 50 per cent. quality, is 50*s.* ex-ship Tees.

Coke.—Deliveries of coke to local blast furnaces are now adequate. Medium quality is 62*s.* 9*d.* at the ovens, and low phosphorus sort is 65*s.* 3*d.* at the ovens.

Manufactured Iron and Steel.—New orders for manufactured iron and steel are very few, but producers are well booked up. Foreign competition is increasingly keen, and reductions in quotations for certain descriptions would cause no surprise. Common iron bars are 30*l.*; marked bars, 32*l.*; iron angles, 30*l.* 15*s.*; steel ship, bridge and tank plates, 24*l.* 10*s.*; steel angles, 24*l.*; steel boiler plates, 31*l.*; soft steel billets, 23*l.* 10*s.*; hard steel billets, 25*l.* 10*s.*; heavy sections of steel rails, 25*l.*; fish plates, 30*l.*; and corrugated galvanised sheets, 40*l.* to 42*l.*

Shipments of Iron and Steel.—Official returns give the total clearances of iron and steel from the port of Middlesbrough for the month of September at 74,224 tons, as compared with 57,616 tons for August. Last month's shipments comprised 44,134 tons of pig-iron, 4,019 tons of manufactured iron, and 26,071 tons of steel. Of the pig-iron despatched, 19,792 tons went coastwise, and 24,342 tons went abroad. The largest customers were: Scotland, 13,685 tons; Belgium, 10,248 tons; the United States, 4,100 tons; and the Tyne, 2,456 tons. Only 419 tons of manufactured iron went coastwise, 3,600 tons going to foreign ports; and of the steel loaded, 3,475 tons went coastwise and 22,596 tons went abroad. India was the heaviest buyer of both manufactured iron and steel, receiving 2,583 tons of the former and 6,462 tons of the latter. Other principal receivers of steel were: Argentine, 3,552 tons; Japan, 2,434 tons; Russia, 1,340 tons; Natal, 1,074 tons; and Cape Colony, 1,059 tons.

Wages.—The accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England have certified the average net selling price of iron bars and angles for the two months ending August 31 last at 30*l.* 0*s.* 10·94*d.*, as compared with 28*l.* 8*s.* 0·24*d.* for the previous two months, and under sliding scale arrangements this gives an advance of 15 per cent. on puddling and all other forge and mill wages as from the 27th ultimo, raising wages to 230 per cent. above the standard. Steel-workers wages at Consett have automatically advanced this quarter by 22½ per cent., raising them to 198 per cent. above the pre-war basis.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—In view of the miners having suspended strike notices till the 16th, to take a ballot on the owners' datum line proposal, there has been a revival in export business during the past week. While coal prices for spot shipment have receded to the extent of 15*s.* a ton, freights for Italy have increased about 100 per cent. and to France about 50 per cent. This is due to the fact that, anticipating a strike, shipowners who were unable to secure coal cargoes outwards sent their boats away in ballast. In fact, in the nine months ended September, 1,036 vessels were cleared foreign in ballast, compared with only 345 in the corresponding period of 1913. At the same time export releases, which had previously been sparingly granted, were freely passed, irrespective of destination, in order that collieries might secure a quick return of empty wagons. Further, collieries were only too eager to supply contractors with arrear quantities in cases where shipment could be obtained, and as prices for contract quantities generally were much below the ordinary market quotations, shippers were ready to pay considerably higher freights and take advantage of the coal position. Genoa options in fact jumped from 25*s.* last week to 50*s.*, and Rouen from 19*s.* to 32*s.* 6*d.*, while River Plate at 52*s.* 6*d.* and Rio de Janeiro at 55*s.* established the highest rates for the current year. On the other hand, spot coals, which last week were practically unobtainable at 115*s.* for large, were freely available down to 100*s.*, with throughs down to 90*s.*, compared with 105*s.* Smalls were relatively steady at 90*s.* to 95*s.* The Council of the South Wales Miners' Federation has recommended the men to vote solidly against the acceptance of the owners' offer, and though it is confidently believed that a national strike will be averted, it is expected that sectional stoppages are likely to be prevalent in South Wales. This week several collieries were rendered idle by the men refusing to go to work as a protest against the Government not having granted the original claim of the miners, but these stoppages were only of brief duration and, should the datum line proposal be accepted, it is more than likely that South Wales would eventually fall into line.

The Iron and Steel Trades.—The markets are in a state of depression, and as far as actual business is concerned there is next to nothing doing. Many of the steel, tin plate and sheet works are working short time, whilst some of the steel works are actually closed, the continual labour unrest making it practically impossible for merchants this side to compete with foreign competitors. The demand for tin plates is limited, and for prompt delivery standard sizes are worth about 50*s.* a box, with 49*s.* asked for delivery next spring. Galvanised sheets are stagnant, with 24-gauge corrugateds offered at 40*l.* to 41*l.*, or a 1*l.* less than a week ago.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The conditions prevailing in the Scotch steel trade show little change over the week, and although there have been few new contracts of any importance fixed up, there has been quite a steady demand for deliveries against existing contracts. The unsettled state caused by the present labour troubles has affected buying, but the further postponement of the miners' strike is being looked upon as a good omen, and it is generally expected that the terms now offered by the mineowners will be acceptable to the miners. Should that be the result of the fresh ballot, one of the most disastrous strikes of modern times will be averted and buyers will again be placing their orders with more freedom and confidence. With almost all the shipyards very busy the consumption of plates continues on a large scale, but there has been little improvement in the demand for angles and other sectional material, and orders for these would be very acceptable at the present time. Sheetmakers are still busy with quite a lot of work on hand, but as semi-manufactured material has eased in price a substantial reduction has been made in quotations. All gauges are reduced, and the new prices, subject to the usual extras, are as follows: Sheets, $\frac{7}{16}$ in. and over, 36*l.* per ton; $\frac{7}{16}$ in. to ¼ in. 36*l.* 10*s.*, per ton; under ¼ in. to 12 gauge 36*l.* 15*s.* per ton; under 12 gauge to 16 gauge, 37*l.* per ton; under 16 gauge to 20 gauge, 37*l.* 5*s.* per ton; under 20 gauge to 24 gauge 37*l.* 10*s.* per ton; under 24 gauge to 27 gauge, 38*l.* 10*s.* per ton; all free on trucks at makers' works. Galvanised sheets are quieter, but a fair demand exists all the same. The general export trade improves but slowly as the amount available for shipping is not of large proportions, and another factor of no little importance is the financial position abroad.

Scotch Pig-Iron Trade.—The Scotch pig-iron makers continue busy and report a steady demand for both foundry and hematite iron, the scarcity of which is still pronounced. The local trade is swallowing up most of the present output, but some small lots are finding their way overseas. Prices are firm for home business, but a shade easier for export lots.

Scotch Shipbuilding.—The Scotch shipbuilding returns for the past month are both interesting and instructive from various points. The number and tonnage of vessels launched in the different districts are as follow:—

	September.		Nine Months.	
	Vessels.	Tons.	Vessels.	Tons.
The Clyde	24	49,251	166	489,425
The Forth ...	3	2,000	26	40,238
The Tay	1	1,280	6	11,903
The Dee and Moray Firth	1	15	35	8,659
	29	52,546	233	550,225

The Clyde total is not the largest month's output for this year and actually only ranks fifth, and it is also the smallest September total since 1910. Nevertheless it has helped considerably towards creating a new record by increasing the nine month's total to 489,425 tons, which is 1,240 tons higher than the previous best, which was in the year 1913, when the output was the record total of 488,180 tons for the corresponding period. In the final three months of that year the output amounted to over 268,000 tons, which it would seem almost impossible to equal this year, on account of the "ca' canny" policy which prevails throughout the country. There are plenty of orders on hand, but the difficulty in securing the necessary ship plates, &c., is one of the greatest factors against a probable new record. Scarcity of supplies has caused a slowing down in some yards, and a fair amount of unemployment is general on the Clyde. Fresh bookings are practically at a standstill owing to the excessively high cost of new tonnage, and many contracts placed some time ago have been cancelled, not only on Clyde but also on the East Coast. The shipbuilding outlook for next year is not over bright, but with plenty of work for the immediate future a turn for the better may take place in time to save any slump in the industry.

NOTICES OF MEETINGS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, October 9, at 2 p.m., General Meeting in the Wood Memorial Hall, Newcastle-upon-Tyne. The following papers will be open for discussion: "A few Notes on Coal-dust Experiments," by Mr. R. W. Anderson, M.C., B.Sc. [Trans. Inst. M.E., vol. lix, page 256]; "The Electric Welding of a Corroded Boiler Shell," by Mr. A. Kenneth Dawson. The following paper will be read or taken as read: "Steam Economy," by Mr. Philip Kirkup, Junr., D.S.O., M.C.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, October 9: In the afternoon, by the courtesy of Sir W. G. Armstrong Whitworth and Co., Limited, the members will have the privilege of visiting their Openshaw Works, the proceedings to commence at 2.30 p.m. In the evening the usual General Meeting will be held at the Memorial Hall, Albert-square, Manchester, for the consideration of the following business: (1) Presentation of the "Constantine" medal for the past session; (2) Presentation of the "Butterworth" medal for the past session; (3) Inaugural Address by the president, Mr. Henry Pilling, M.B.E., M.I.Mech.E. The chair will be taken at 7 p.m. prompt.

THE AIR CONFERENCE, 1920.—Tuesday, October 12, at 10 a.m., in the Guildhall, London. Members of the Conference will be welcomed by the Lord Mayor, after which Major-General Sir F. H. Sykes, G.B.E., K.C.B., C.M.G., will deliver a lecture on "Civil Aviation and Air Services." At 3 p.m., Mr. H. White Smith will lecture on "The Operation of Civil Aircraft in Relation to the Constructor," Lord Montagu of Beaulieu presiding on both occasions. Wednesday, October 13, at 10.30 a.m. Air Vice-Marshall Sir E. L. Ellington, K.C.B., C.M.G., C.B.E., will lecture on "The Present Position of Aircraft Research and Contemplated Developments," after which the members will visit the Terminal Aerodrome at Croydon, travelling by train from London Bridge at 1.10 p.m. At 5 p.m. in the Guildhall, Captain F. S. Barnwell will deliver a lecture on "The Technical Aspects of Service and Civil Aviation." At both lectures the chair will be taken by Lord Weir of Eastwood. Thursday, October 14, at 10.30 a.m., Air-Marshall Sir H. M. Trenchard, Bart., K.C.B., D.S.O., will lecture on "The Broader Aspects of Service Aviation," and at 3 p.m. Commander Sir Trevor Dawson, Bart., R.N., will lecture on "The Commercial Airship: Its Operation and Construction"; Admiral of the Fleet, Earl Beatty, will preside at both lectures.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, October 12, at 6.30 p.m. "The Screw Propeller—A New Type," by J. H. W. Gill, C.B.E., Member.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS, LONDON.—Tuesday, October 12, at 7 p.m. prompt, in the Philosophical Hall, Park-row, Leeds. Paper by Colonel E. Kitson Clark, on "Articulated Locomotives." Preceded by a visit to Messrs. Kitson and Co.'s Works, Airedale Foundry, Leeds, at 3 p.m., where articulated locomotives will be shown.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, October 13, at 7.30 p.m. prompt, at St. Bride's Institute, Bride-lane, Fleet-street, a paper will be read by Mr. Leon Gaster, on "Progress in Industrial Lighting." Mr. Haydn T. Harrison, M.I.E.E., in the chair.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 15, at 8 p.m., at 39, Victoria street, S.W. 1, Lecturette "Elementary Physics and Chemistry in Relation to Motor Cars," by Mr. R. S. Fax, M.A., A.M.I.A.E., Member.

THE ROYAL SOCIETY OF ARTS.—Friday, October 15, at 4.30 p.m., Indian Section. "British Trade with India" by Mr. Thomas M. Ainscough, O.B.E., H.M. Senior Trade Commissioner in India and Ceylon. Sir Charles C. McLeod will preside.

THE POSITION OF THE SWEDISH SHIPYARDS.—According to the statistics of *Norske Veritas* on the Scandinavian mercantile marine, referred to in *Swedish Export*, Sweden had under construction, at the beginning of July, 69 vessels of 114,698 tons gross, while 45 vessels of 146,450 tons gross had been ordered but not yet begun. A private inquiry has shown that no negotiations have been opened for the annulling of contracts, whereas the contrary is the case in England and Japan.

SOUTH AFRICAN TRADE WITH SCANDINAVIA.—We read in *The South African Mining and Engineering Journal* that a contract for the immediate delivery of South African Witbank coal has been concluded, 20,000 tons going to Gothenburg. Later 40,000 tons will also probably be delivered at Gothenburg. The deal has been made with the African-Scandia Co-operative Company, Limited, of Johannesburg. In order to extend its sphere of activity, this company has absorbed a large South African export firm. It has, furthermore, acquired the sole right for the sale of the paper of many Swedish mills, and of other industrial products. The object of all this is to arrange trade between Scandinavia, especially Sweden, and South Africa, without the help of numerous middlemen, through whom business has been transacted hitherto. The Swedish Government has directed its attention to the new coal market, and in the investigation begun some time ago by the Trade Commission, regarding measures for securing the country's supply of coal, due attention is being paid to South Africa. Shipments of coal have already been begun, and the prospects for their continuation are said to be favourable.

TRACTORS AT THE ROYAL AGRICULTURAL SOCIETY'S TRIALS AT LINCOLN.

(*For Description, see Page* 472.)

Fig. 5. The Chase Tractor.

Fig. 6. The Parrett Tractor.

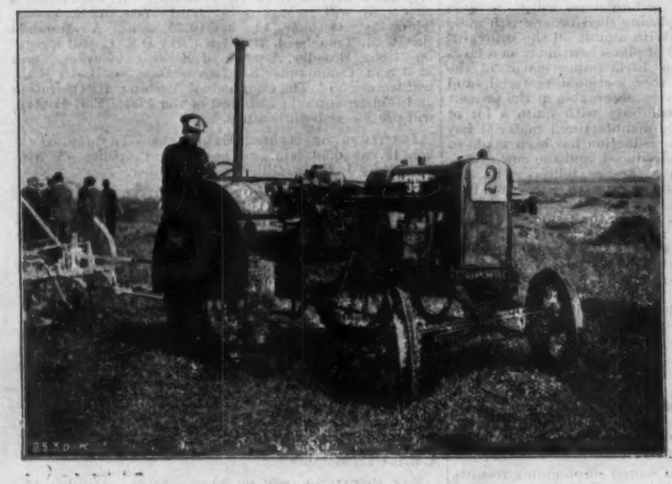


Fig. 7. The Hart-Parr Tractor.

Fig. 8. The G. O. Tractor.

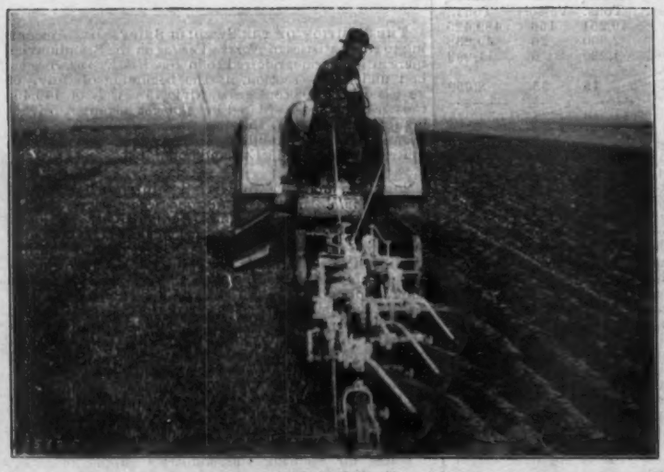


Fig. 9. The Twin City Tractor.

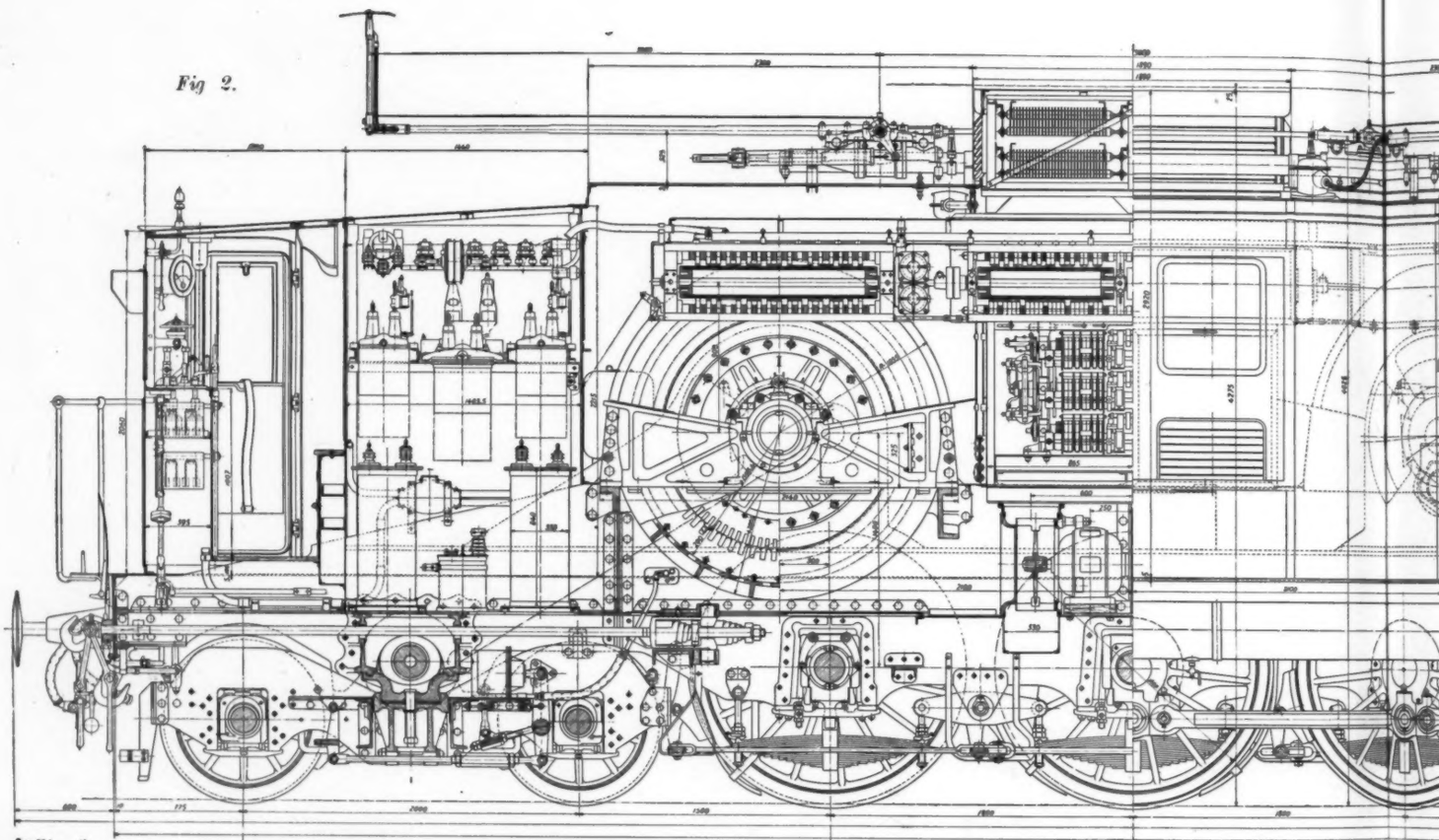
Fig. 10. The Cletrac Tractor.

THREE-PHASE 4-6-4 TYPE ELECTRIC LOCOMOTIV

CONSTRUCTED BY THE OERLIKON WORKS COMPANY,

(*For Descriptio, see Pa*

Fig 2.



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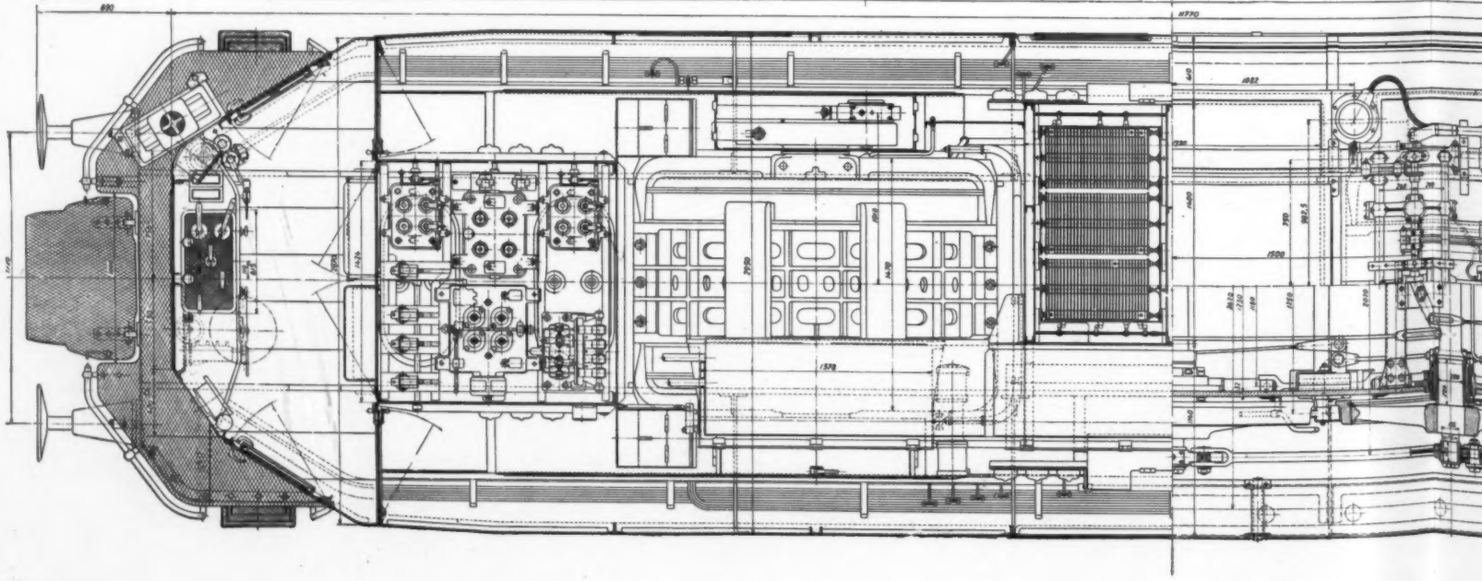
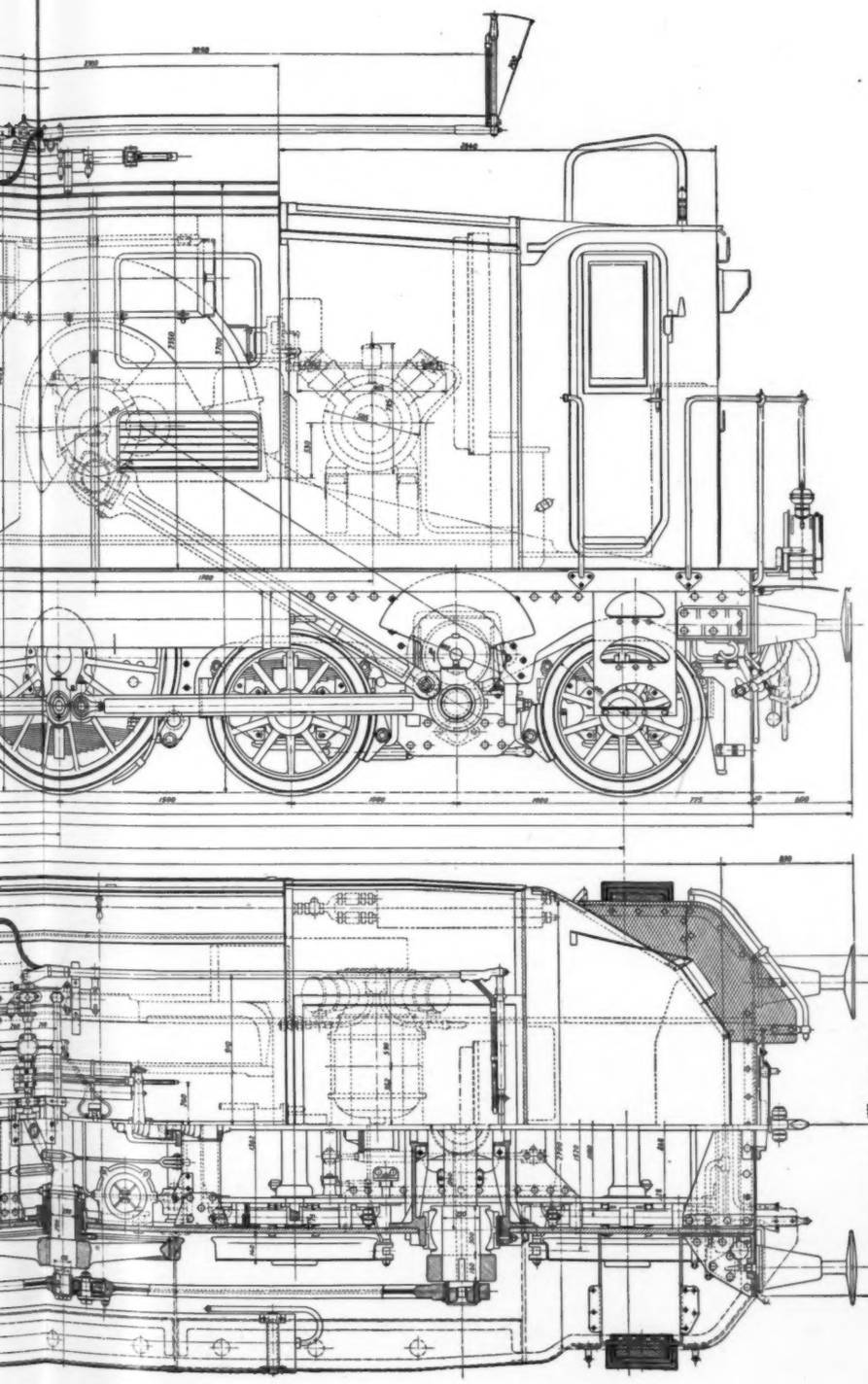


OMOTIVE FOR THE ITALIAN STATE RAILWAYS.

KS COMPANY, ENGINEERS, OERLIKON, SWITZERLAND.

scription, see *Page* 469.)



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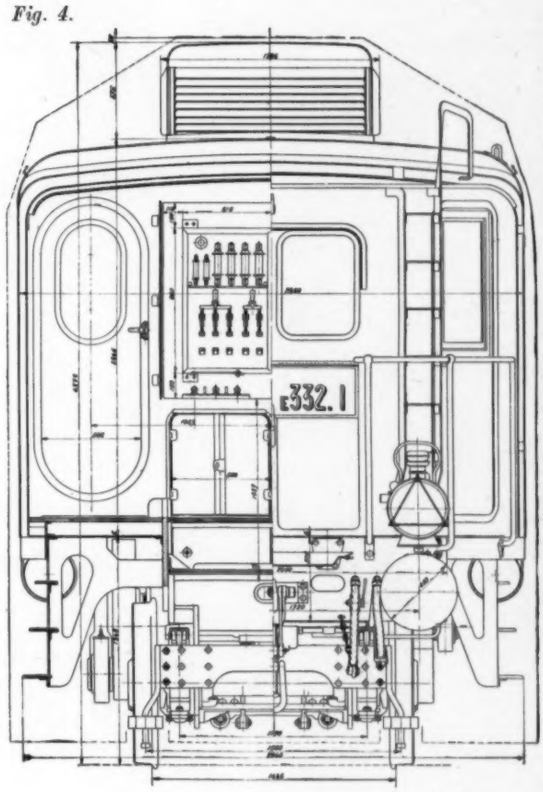
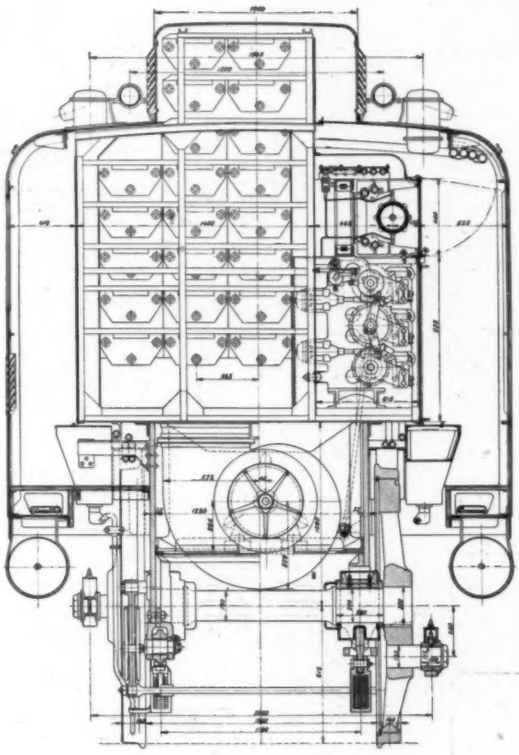


Synchronous speed at $16\frac{2}{3}$ periods km. per hour	37·5, 50, 75, 100
Synchronous speed at $16\frac{2}{3}$ periods miles per hour	23, 31, 46, 62
Continuous rating horse-power ...	1,250, 1,670, 2,640, 2,220
Draw-bar pull in kg.	9,990, 9,000, 9,500, 6,000
Draw-bar pull in lbs.	22,000 20,000, 21,000, 13,000
Maximum draw-bar pull in kg.	12,000
Maximum draw-bar pull in lbs.	26,000
Normal overhead line voltage ...	3,300
Normal period per second ...	$16\frac{2}{3}$
Track gauge	1,435 mm. (4 ft. $8\frac{1}{2}$ in.)
Diameter of driving wheels ...	1,630 mm. (64 in.)
Diameter of bogie wheels ...	960 mm. (38 in.)
Length overall	13,370 mm. (44 ft.)
Total wheel-base	10,600 mm. (35 ft.)
Rigid wheel-base	3,600 mm. (12 ft.)
Bogie wheel-base	2,000 mm. (6 ft. 4 in.)
Distance between bogie centre pins	8,600 mm. (28 ft.)
Weight of mechanical part ...	49·3 metric tons.
Weight of electrical part ...	42·7 metric tons.
Load on each driving axle ...	18 metric tons.
Adhesive weight	54 metric tons.

THREE-PHASE 4-6-4 TYPE ELECTRIC LOCOMOTIVE FOR THE ITALIAN STATE RAILWAYS.

CONSTRUCTED BY THE OERLIKON WORKS COMPANY, ENGINEERS, OERLIKON, SWITZERLAND.

(*For Description, see Page* 469.)



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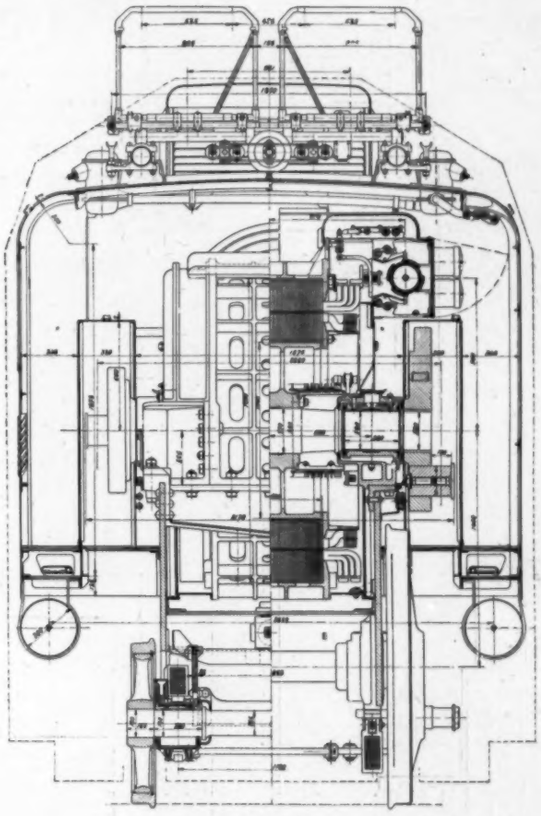
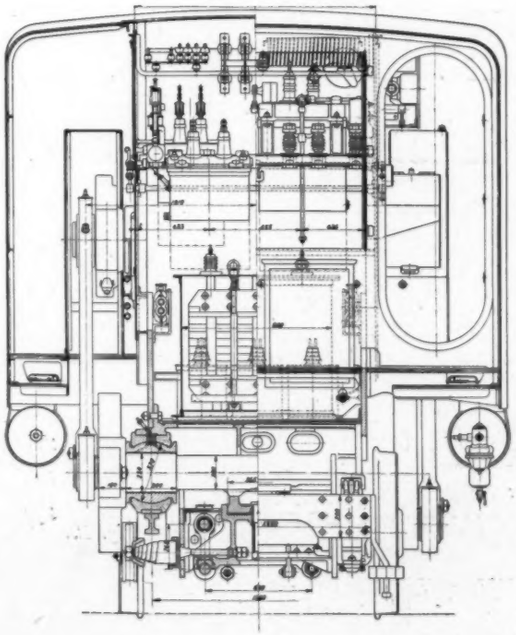


Fig. 6.



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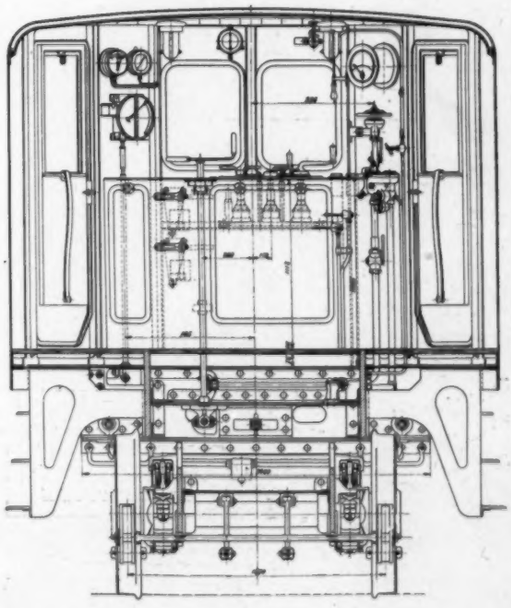


Fig. 8.

(*To face page* 470.)

DIAGRAM OF CONNECTIONS FOR THREE-PHASE 4-6-4 TYPE ELEC

CONSTRUCTED BY THE OERLIKON WORKS CO

(For Description, see Pag

Fig. 9.

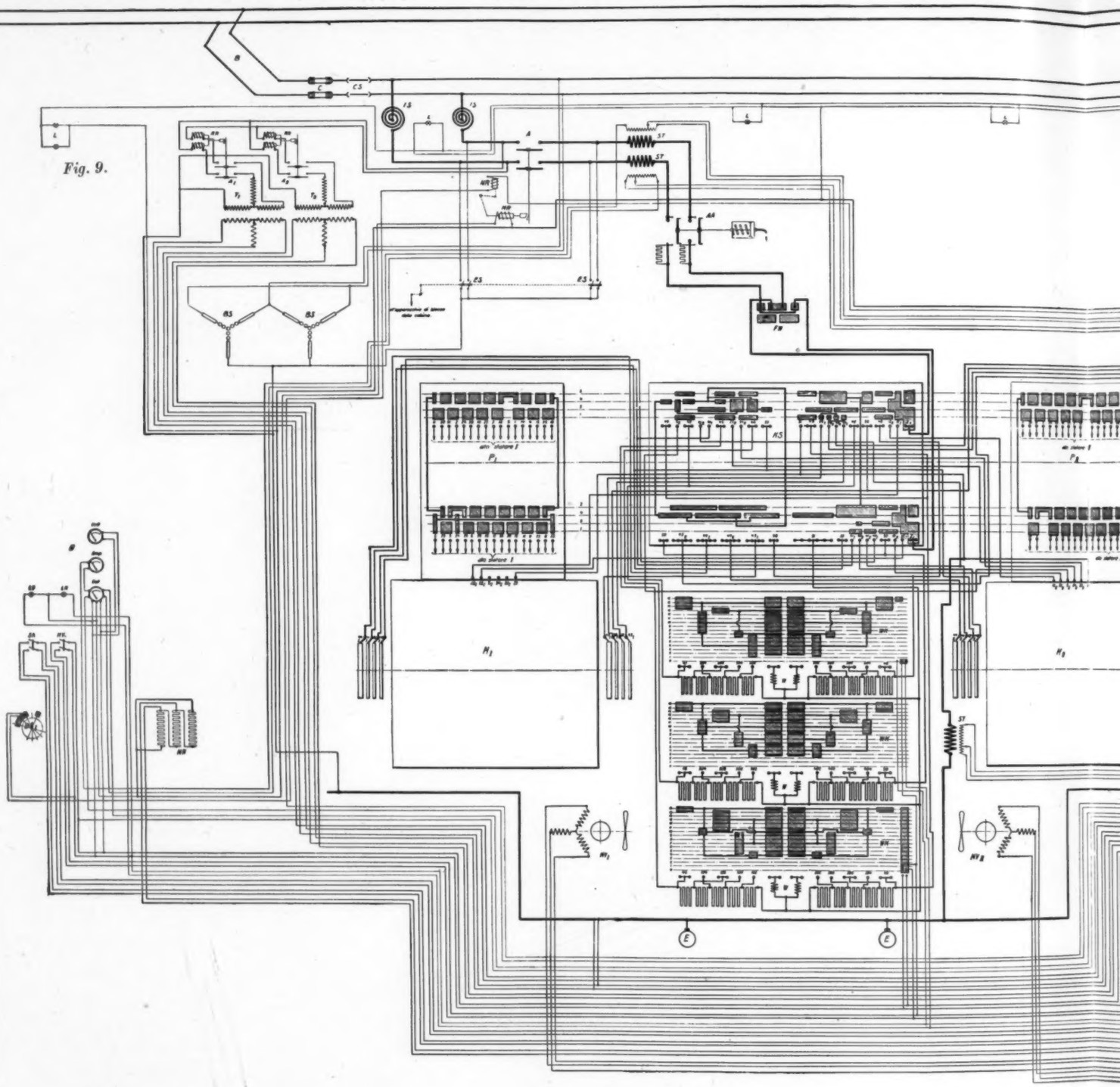
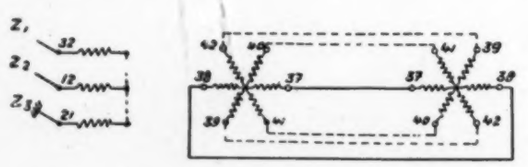


Fig. 10.



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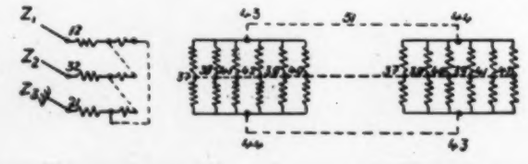

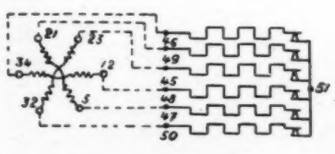

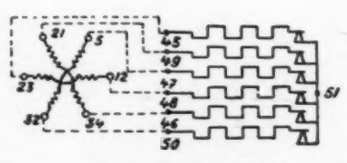

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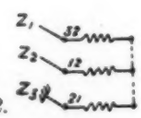
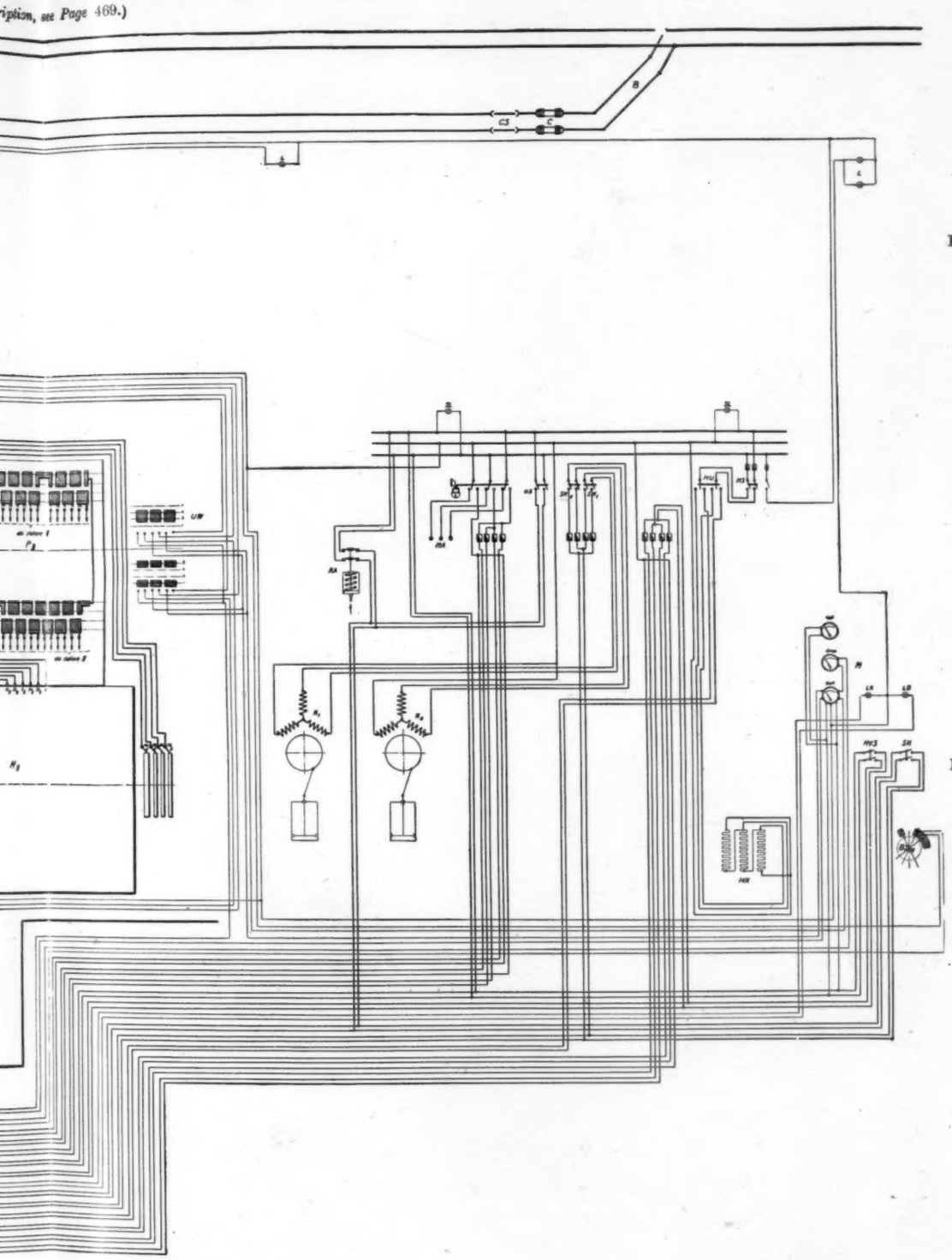


E ELECTRIC LOCOMOTIVE FOR THE ITALIAN STATE RAILWAYS.

WORKS COMPANY, ENGINEERS, OERLIKON, SWITZERLAND.

ription, see Page 469.)



A.	Main oil switch.
AA.	Oil switch for motor.
A_1, A_{11}.	Oil switches for transformers.
B.	Current collector.
BS.	Lightning arrester.
BS_1, BS_{11}.	Control valves for current collector.
C.	High tension leads.
CS.	Isolating links.
E.	Earthing slip-rings.
ES.	Earthing switch.
FW.	Reversing controller.
HK.	Heating elements.
HS.	Heating switch.
HU.	Reversing switch for heater.
JS.	Induction coils.
K_1, K_{11}.	Compressor sets.
KA.	Automatic pressure regulator.
KS.	Cascade switch.
L.	Incandescent lamps.
LK.	Lamp for control position 16.
LO.	Lamp for control position 0.
M.	Recording instruments.
M_1, M_{11}.	Motors.
MA.	Terminals for depôt connections.
MR.	Maximum current relay.
MV_1, MV_{11}.	Cooling fan sets.
MVS.	Cooling fan switch.
NR.	No-voltage relay.
P_1, P_{11}.	Pole-changing switch.
SK.	Main switch for compressor supply.
SK_1, SK_{11}.	Compressor switches.
SL.	Signal lamps.
ST.	Current reverser.
T_1, T_{11}.	Transformers for auxiliaries.
US.	Short circuit to pressure regulator.
UW.	Switch for recording instruments.
W.	Starting resistance.
WK.	Contact barrels of resistance controller.

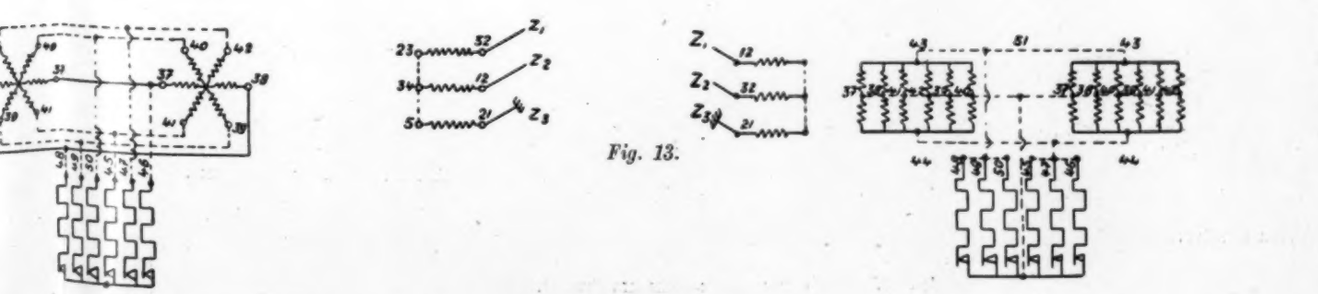


Fig. 13.

THREE-PHASE 4-6-4 TYPE ELECTRIC LOCOMOTIVE FOR THE ITALIAN STATE RAILWAYS.

CONSTRUCTED BY THE OERLIKON WORKS COMPANY, ENGINEERS, OERLIKON, SWITZERLAND.

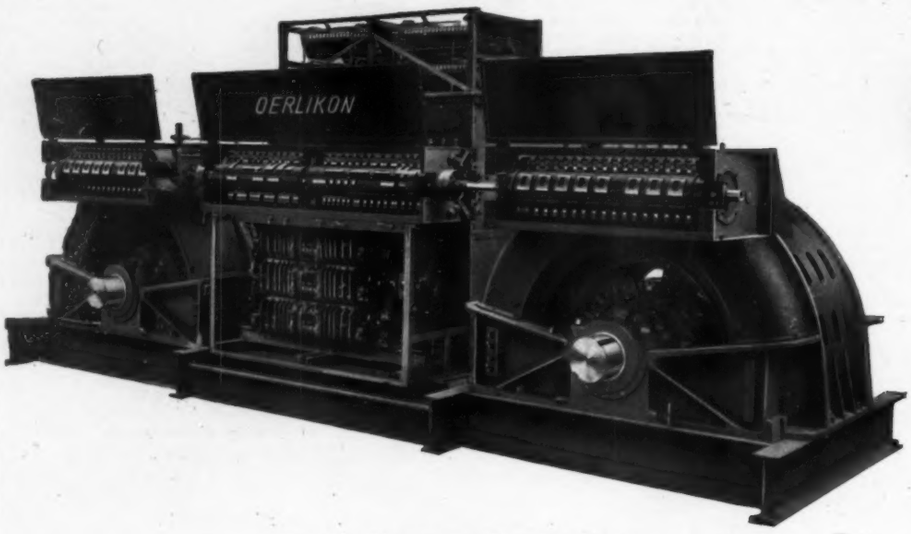


Fig. 14. Motors and Main Apparatus.

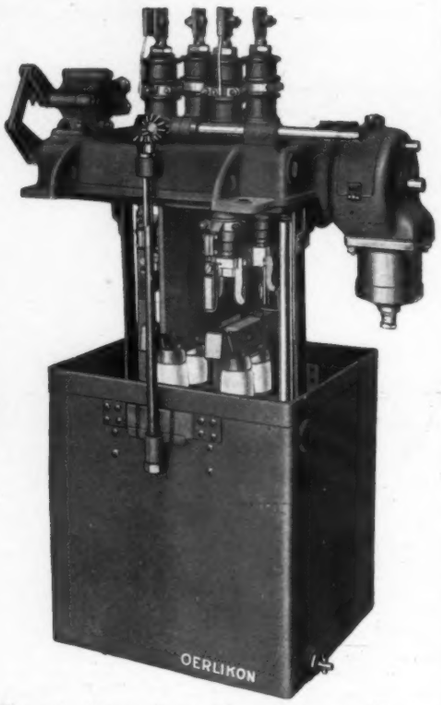


Fig. 18. Motor Switch with Pneumatic Relay.

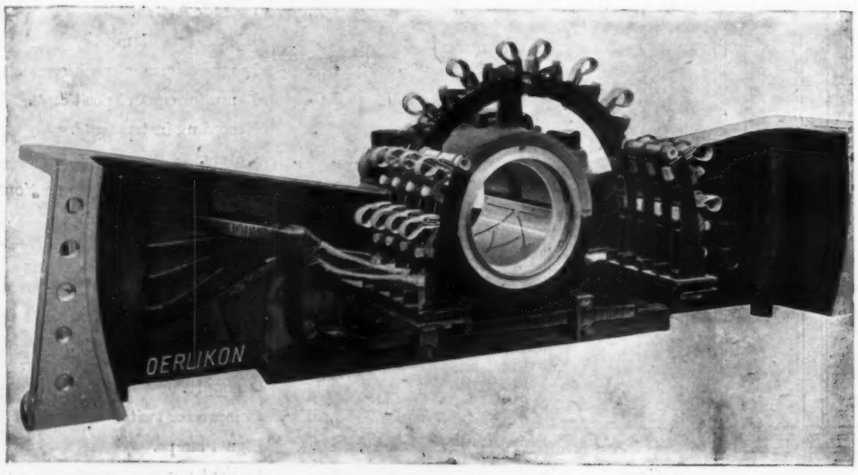


Fig. 15. Bearing and Brush-Holder for Motor.

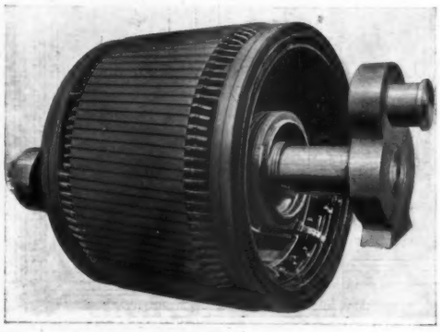


Fig. 19. Rotor of Main Motor.

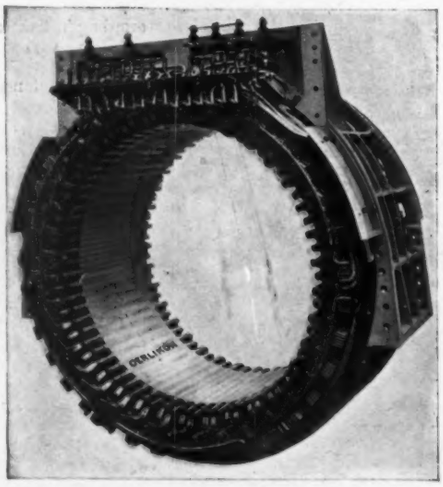


Fig. 16. Stator of Main Motor.

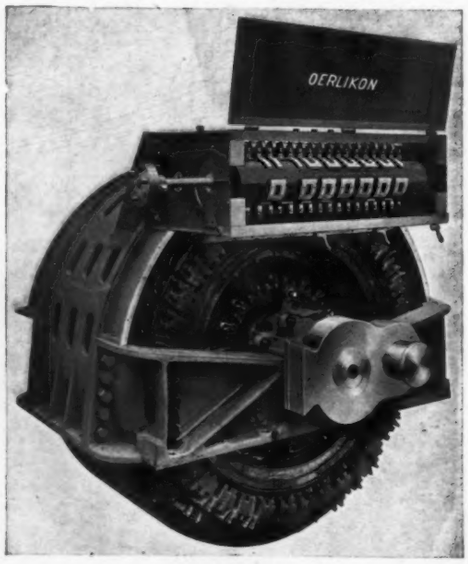


Fig. 17. Motor with Pole-Changing Switch.

Fig. 20. Earthing Slip-Ring.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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TELEPHONE NUMBERS—3683 and 8598 GERRARD.

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With Two Two-Page Plates and Two One-Page Plates of the THREE-PHASE 4-6-4 TYPE ELECTRIC LOCOMOTIVE FOR THE ITALIAN STATE RAILWAYS.

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. As the postal rates have been again increased, the price of single copies sent by inland post is now 1s. 2½d.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 475.

ENGINEERING.

FRIDAY, OCTOBER 8, 1920.

THE EIGHT-HOUR DAY.

IT is possible for the physicist in his laboratory to conduct his investigations in such fashion as to secure a whole series of observations in which but one variable at a time is altered, a procedure which naturally greatly simplifies his problem. Outside of the laboratory it is, however, seldom possible to arrange matters in this convenient fashion. With each change of conditions several variables alter and the practical man is confronted daily with the necessity of drawing sufficient conclusions from insufficient premises. Most statistical inquiries are of this character, but so far as our experience goes very few professed statisticians recognise the fact, but like Sir Chiozza Money, for example, think it is quite legitimate to compare, say, the works cost of power stations having entirely different load factors, or the cost per mile of a railway run through the plains of Germany with the cost in such an undulating country as Great Britain.

The war originated many inquiries into the operation of factories. At the outset, the common accountant's view was taken that output was directly proportional to the hours worked, with the consequence that production was lowered and costs increased by excessive overtime. It is a striking commentary on the difficulty of assimilating other peoples experience, that when America entered the war and recognised the need for intensified production she made the same mistake, and then, like ourselves, settled down to try and determine by direct observation the connection between output and hours of labour. It cannot be said, either here or in America, that sufficient data have yet been acquired to establish the true connection between the two, but here we have in some few instances secured results which seem to be reasonably comparable. Thus in one factory where boys were employed in large numbers on turret lathe work, and paid by the piece, it was found that reducing the hours worked by 18 per cent. led at first to a nearly proportionate decrease of output, but week by week the figure rose, and at the end of three months was within 3 per cent. of its original value. This result is particularly interesting as it was obtained with a class of work in which output is not generally held to be to any very large extent dependent on the human factor.

In this instance the conditions appear to have been strictly comparable: the work was the same and at the same factory and under, we presume, the same management. When, however, an attempt is made to draw conclusions as to the most advantageous length of the working day from comparisons between two factories, differently situated, making different products and under different management, it is only a Fabian statistician that would have confidence in his deductions. Nevertheless, such a comparison, though necessarily unreliable, is not without interest when based on data well selected, honestly observed and adequate in number. These conditions are certainly fulfilled in the case of an inquiry into the working of two large factories, described in a report recently published by the United States Public Health Department.* The investigation was made and the report drawn up by officials of the United States Public Health Service, who obviously secured the hearty co-operation of the management of the two undertakings in question. Of the two, the larger was an old-established motor car factory, covering 88 acres of ground and employing some 36,000 hands. The concern in question is presumably one of the Ford establishments, though this is not definitely stated. This factory is run on the three-shift system, each shift being of 8 hours' duration. In the night shift, however, only 8 per cent. of the employees are at work. Overcrowding at times of change of shift is provided against by a division of the workers into sections, each of which comes to work 15 minutes later than its predecessor. The operatives for the most part own their own houses, and excellent provision is made for them during the dinner hour. During the time of the inquiry, which extended over six months, the number employed at this plant was nearly stationary.

The other plant was operated on the two-shift system, the day shift being 10 hours long and the night shift 12. In 1914 it employed 3,600 hands, but on taking up the manufacture of munitions this number increased rapidly, and in 1917 some 13,000 were employed. This sudden influx of workers was accompanied by no adequate provision for housing them; so that there was serious overcrowding and much profiteering on the part of landlords. Moreover, the facilities for dining were far from adequate, so that the workers outside of factory hours were in much less comfortable circumstances than those at the 8-hour plant. Hence, so far as output is affected by matters of this kind, the conditions at the two plants were not comparable. A curious anomaly is that the sickness rate was somewhat higher at the 8-hour plant. Of this no explanation is afforded in the text of the report. It is conceivable, that it may have been due to differences in the working conditions, so that an operative, even if temporarily below par, could satisfy the standard demanded at the 10-hour plant, but might not be able to keep up to that at the 8-hour plant unless perfectly fit. This, however, is a mere conjecture, and the difference may well have been climatic, as the two factories were situated in different towns.

The striking feature of the 8-hour plant was the great regularity of output. The investigators are disposed to attribute this to the shorter hours worked, and it cannot be said that this is improbable, but it is conceivable that this regularity is really to be attributed to the methods employed, which may make it difficult for the output to fall below a certain standard. It was, in fact, found that with certain types of work, in particular lathe work, the hourly output remained constant, although physiological tests showed that the operators were suffering from fatigue at the end of the day. Hence, although it is quite likely that the greater regularity with which the 8-hour plant was operated was largely due to the shorter shift, yet it would be unsafe to infer that this was the sole factor involved.

As already stated, the plants, though employing machinery of similar character, produced entirely different commodities, and thus no direct comparison of outputs was possible. To get round this difficulty the ingenious plan was adopted of taking as the standard of comparison the best hour's output and expressing the output for every other hour of the shift as a percentage of this. The work was, moreover, classified into four divisions, namely: dexterous hand work, muscular hand work, lathe work, and miscellaneous machine work. In few of these sections was the hour of maximum output the same hour of the shift, and it is noteworthy

* *Comparison of an Eight-Hour Plant and a Ten-Hour Plant.* Report by Josephine Goldmark and Mary D. Hopkins, on an investigation by Phillip Sargent Florence and associates under the general direction of Frederic Lee. Washington: Government Printing Office, 1920.

that in some heavy muscular work the output attained its maximum in the first hour of the afternoon shift, whilst in work involving mind to a greater degree, the hour after dinner was commonly characterised by relative low productivity. The annexed table shows the output hour by hour in typical operations; this output being expressed as a percentage of the maximum for each of certain representative operations as enumerated:—

TABLE I.—Output Maintenance with Eight-Hour and with Ten-Hour Working Day.

—	—	Operation.	Relative Hourly Output.					Classification of Work.
			First Hour.	Second Hour.	Third Hour.	Fourth Hour.	Fifth Hour.	
			per cent.	per cent.	per cent.	per cent.	per cent.	
8-hour plant	Morning spell	Ramming	95·0	100·0	97·8	92·8	—	Muscular hand work.
	Afternoon spell	Moulds	91·2	88·4	83·1	79·0		
10-hour plant	Morning spell	Planishing	93·6	88·6	83·2	86·5	68·6	
	Afternoon spell	Seats	100·0	85·6	78·2	74·0	54·3	
8-hour plant	Morning spell	Rivet	91·2	95·9	100·0	94·6	—	Dexterous hand work.
	Afternoon spell	Press	94·5	92·9	94·2	891·1	—	
10-hour plant	Morning spell	Fuse	79·9	98·9	100·0	98·7	90·6	
	Afternoon spell	Assembly	84·1	93·3	92·6	91·3	84·1	
8-hour plant	Morning spell	Rear axle	87·9	93·9	94·4	96·3	—	Lathe work.
	Afternoon spell	Housing	100·0	96·7	92·1	90·7	—	
10-hour plant	Morning spell	Spin top cap	89·5	86·4	94·5	100·0	97·3	
	Afternoon spell		93·2	92·3	95·9	93·6	93·2	
8-hour plant	Morning spell	Crank-case	86·8	94·5	100·0	96·6	—	Miscellaneous machine work.
	Afternoon spell	Grinding	92·2	92·2	98·7	98·3	—	
10-hour plant	Morning spell	Buffing razor	86·0	94·2	97·5	100·0	98·0	
	Afternoon spell	Frames	94·2	99·6	99·6	98·4	86·8	

Taking all operations into account the average hourly efficiency at the 8-hour plant was 94 per cent., that at the 10-hour plant being 90·2 per cent. Hence, if 100 per cent. efficiency meant the same thing at both plants the relative day's output at the two plants would be represented by the numbers 752 and 902, showing a large gain for the longer hours. Thus if for purposes of illustration we assume that both works were producing bolts, and that in each case, the maximum output was 100 bolts per hour, the eight-hour plant would produce $8 \times 94 = 752$ bolts per day, and the ten-hour plant $10 \times 90{\cdot}2 = 902$ bolts per day. If, however, the maximum hour's output at the ten-hour plant was 70 bolts instead of 100, the daily output at this plant would be $10 \times 70 \times {\cdot}902 = 631{\cdot}4$ bolts, or considerably less than at the eight-hours factory. The eight-hour plant is, in fact, famous for its low labour cost per unit of work done, in spite of high rates of pay. The 10-hour plant on the other hand was in a process of very rapid growth, and hence had a very much larger proportion of hands inexperienced in their work than was the case at the 8-hour factory. It is thus hardly conceivable that the standard of comparison for output was as high as at the 8-hour plant.

In spite of its rapid growth the "turnover of labour"—a term now adopted to denote the change of employees—was very high at the 10-hour plant, being six times as much as at the 8-hour plant. Thus in the year 1918 the labour turnover was 176 per cent., as against 30 per cent. at the 8-hour establishment. For this difference there were many reasons. As already pointed out, the conditions outside the 10-hour factory were far from comfortable; and although the hours worked were longer, the rate of pay was much lower than at the 8-hour establishment, the average earnings on piece in 1918 being 3·20 dols. per day for men and 2·80 dols. for women. At the 8-hour plant all workers, skilled and unskilled and more than 18 years old, were, even in pre-war times, guaranteed a minimum of 5 dols. per day. Moreover, a candidate for employment had to pass a medical examination, so that men with weak hearts or suffering from hernia should not be put on work requiring heavy lifting, or those with weak lungs set to work in dusty conditions. These precautions no doubt tended to diminish the labour turnover, but it is notable that, as already mentioned, the recorded sickness rate was greater at this 8-hour establishment than at the 10-hour, an anomaly which appears worthy of further investigation. Another feature of the management which tended to diminish turnover at the 8-hour works was the facilities provided for the transfer of workers, at their own request, from one department to another. Only a fraction of such demands were granted, but the possibility of transfer did tend to make the employees less inclined to move, and those who did were always asked to give a reason for their departure, with a view to detecting and eliminating unsatisfactory conditions as they arose. The turnover was highest in departments where there was most smoke and fumes or noise. It is noteworthy, however, that the small tool department had also a high turnover. This appears to be due largely to the fact that the management have standardised matters so that no preference is shown for special departments on the score of higher pay, and the highly-skilled men in the small tools department got no more than if they had been employed by other firms, although the unskilled and semi-skilled operatives were paid much more highly than if engaged elsewhere.

This matter of reducing labour turnover is an important one owing to the cost of training new men. An inquiry made by the United States Bureau of Statistics led to the conclusion that the average cost of "hiring and firing" a new hand ranged from 33·50 dols. for one of the clerical force up to 85·3 dols. for a piece-work operative who can become efficient within a few months. The consequent charge to the factories investigated amounted yearly to 3½ per cent. of the total pay roll. This figure would probably correspond to an amount sufficient to pay 30 per cent. on the capital. According to another estimate "breaking in a new man" in a machine shop costs 65·40 dols., but in view of the fact that six men are hired for one who stays long enough to become skilled, "the final cost per experienced man" is found to exceed 100 dols.

Both the 8-hour and the 10-hour establishments were run on the principle of "safety first," and had surgeries and nurses under competent medical direction. In both cases the employees were urged not to neglect even slight mishaps, and as a consequence the accident roll attained apparently appalling dimensions. Thus even at the 8-hour plant the three months' total was 13,205 accidents distributed over a total of 36,000 hands. It is, however, essential to bear in mind that nowadays trivial cuts and abrasions, which thirty years ago would not have led to more than a few minutes' loss of time, are now recorded as accidents. It may be recalled in this connection that Mr. Sidney Webb, at the Coal Inquiry, made the characteristically ridiculous statement that the casualties in the coal trade per annum equalled those of the Expeditionary Force at Gallipoli. Such a comparison is, of course, absurd, and even if deaths only were counted a correction would be necessary, owing to the fact that in the coal trade an accident is accounted fatal if death occurs within the succeeding twelve months.

The claim has been made that accidents increase with the rate of output, and generally very much faster than the output. Without very material qualification such a statement is inherently absurd, since by the adoption of improvements in working, output may be enormously increased, whilst the accident rate may be simultaneously diminished. Thus inquiries made in this country during the war showed that the adoption of jigs led to a reduction in the accident rate, whilst it certainly materially increased the output. Nevertheless, it is a plausible hypothesis that in identical operations, the accident risk is proportionate to the number of operations made, that is, to the output. Experience shows, however, that this hypothesis is only partially true, and is subject to many exceptions.

In the report now under review the accidents reported were tabulated hour by hour for the various classes of work, determining in this way the hour of minimum risk. When the figures thus tabulated were compared with the rates of output there was far from complete correlation between the two. Fatigue is evidently a factor involved, so that in the later hours of the day, although the output is reduced and the number of accidents fall, this fall is proportionately less than the fall in production. According to a statement published by Dr. Vernon in a report on the Health of Munition Workers, published in 1918, the relation between output and accidents was such that a variation of 1 per cent. in the output rate was accompanied by a variation of 4 per cent. or more in the accident rate. Were this true the accident rate should diminish in the later hours of the day much more rapidly than the output, but the reverse is the case. The relation between output and liability to accidents is evidently a very complicated one. In the case of machine work, the American observers find that under certain very limited conditions Dr. Vernon's estimate may hold. In the case of hand work, however, the accident rate, so far as it depends on output, varies only at about the same rate as the output instead of four times as fast as Dr. Vernon asserted.

SOUTH AFRICAN IRON AND STEEL.

Numerous reports have been made during the last few years on the occurrence of iron ores in South Africa, and the possibility of establishing a large iron and steel industry has been more or less hopefully discussed for the past quarter of a century. It has even been suggested that not only could the home market for iron and steel goods be fully supplied, but an export trade could also be developed. It will be sufficient, however, for the present to confine attention to supplying the home market which is already very large, and will doubtless expand considerably.

Some idea of the size of this market was given by Professor Harbord in 1910, when he reported to the Transvaal Government that the importation of finished iron and steel goods in 1906, 1907 and 1908 averaged 100,000 tons to 110,000 tons. He estimated the possible local production at 50,000 tons of all classes of metal plates, galvanised sheets, hoop iron, fencing, wire, &c.; but he expressed the opinion that the manufacture of rails, sleeper bars, wire, &c., would not be commercially successful under the then prevailing conditions. Interest in the subject then waned for a time.

Conditions are now radically different, foremost among these being the greatly increased cost of production in present producing countries and the high freights. Professor Stanley, of the South African School of Mines, has gone into the matter very thoroughly, and not only carried out numerous investigations on his own account, but collated much valuable information from other authorities. As a result of his investigations he concludes that the following is a rough approximation of the iron and steel goods required annually in South Africa and capable of production in a steel-works of moderate size.

	Tons.
Rails, crossing, &c., for railways ...	65,000
Rails for mines	12,500
Angles and channels	5,000
Bars, bolts and rods	21,000
Girders, beams and columns	8,000
Plate and sheet	10,000
Bolts, nuts and washers	2,500
Fencing standards	25,000
Drill steel	6,000
Shoes and dies	7,500
Steel castings	2,500
Pig iron...	10,000
	175,000

The estimate for pig iron may seem too high, but it will be remembered that, owing to the war,

machinery is being made and repairs executed locally, and this will increase if only the necessary iron is available; while there is an increasing demand for light castings for agricultural and similar machinery, and also for pipes. Scrap metal is, moreover, very scarce. It is difficult to estimate the cost of manufacturing pig in South Africa, but if the works were located near the iron ore deposits the cost of the ore should not be more than 3*s.* 6*d.* per ton. Limestone would have to be carried in from a great distance and would cost up to 20*s.* per ton. The cost of fuel is problematical, but Professor Stanley estimates it at about 1*l.* per ton if coke be used on a fairly large scale and by-products are recovered. Including ore, fuel, limestone, labour, repairs and sundries, management, interest and depreciation, the cost per ton of pig iron is put at 3*l.* 4*s.*, which is less than half the pre-war price of imported pig in the interior. The cost of conversion to steel is still more difficult to calculate, but it is thought that the pre-war selling price of the various classes of material, say, 17*l.* per ton to 20*l.* per ton, should leave a very satisfactory margin of profit, since the difference in price of pig iron and finished steel would be 14*l.* per ton to 15*l.* per ton, compared with a difference in Europe of 3*l.* to 4*l.* Then again freight gives the African producer an advantage of about 5*l.*, and increased manufacturing costs are not likely to exceed that amount, and may easily be much less.

Ore Deposits.—Iron ore is found mostly in the Pretoria district, in the Transvaal, and the occurrences there have been variously classified. One classification is that of Mr. T. G. Trevor, Deputy Inspector of Mines, given in the Annual Report of the Government Mining Engineer for 1909–10:—

(*a*) Ore associated with the Bushveld granite:
  (1) Titaniferous.
  (2) Chrome iron ore.
(*b*) Magnetic quartzites of the Pretoria series:
(*c*) Banded hematites of the Swaziland series:
(*d*) Other deposits:
  (1) Hematite of the coal measures.
  (2) Earthy deposits in upper dolomite.
  (3) Hematite in disturbed rocks on the edge of the Bushveld granite.

In strict geological ascending order the Pretoria deposits may be classified as—(1) uppermost beds of the dolomite formation; (2) Timeball Hill zone of the Pretoria series; (3) the so-called clay-band a little above the uppermost quartzite bed of the Timeball Hill horizon; and (4) shales and associated rocks immediately underlying the Daspoort quartzite zone of the Pretoria series. These four divisions are described in some detail in the Bulletin of the Imperial Institute, just issued (*Bull. Imp. Inst.*, 1920, I. 82–92), and also by Professor Stanley in the *South African Journal of Industries*, 1920, May, July and August). It is evident from both reports that enormous quantities of valuable ore are available. The uppermost beds of the dolomite formation, consisting of impure earthy manganiferous ironstone, 15 ft. thick in places, are ruled out as unworkable, but most of the other formations are available. In the Timeball Hill zone the iron content ranges from 40·5 per cent. to 53·6 per cent., and much of the ore could be quarried in open cuts and loaded into trucks at an estimated cost of 3*s.* 6*d.* per ton, while still more could be obtained by adits at about 6*s.* per ton. This ore is sometimes referred to as magnetic quartzite, but it is more correctly described as an arenaceous oolitic ironstone, fine grained, hard and reddish-black in colour, interstratified with Timeball quartzites and shales. The clay-band iron ore is of better quality than that of the Timeball Hill zone, but the layer is less thick and the outcrop less persistent. It is a very fine-grained reddish-brown rock, much jointed, and containing some quartz veins. Its iron content averages 50 per cent. There is a fair amount of ore at the surface or obtainable by stripping the overburden with a steam shovel. Further down the cost should not exceed 10*s.* per ton. If smelted with the siliceous ores, the amount of limestone required to flux the latter is much reduced. The shales in the Daspoort quartzite contain oolitic or pisolitic grains of hematite in a ferruginous sandy matrix, and the iron content is only about 22 per cent., hardly therefore worth working at present.

According to a report, dated July 23, 1919, made by Dr. P. A. Wagner, the lease of the Pretoria Iron Mines, Limited, refers to five areas—A, B, C, D, E. The first area adjoins the Pretoria Mental Hospital and consists mostly of siliceous ironstone or magnetic quartzite, containing between 45·9 per cent. and 53·1 per cent. of iron, and 15·75 per cent. and 25·59 per cent. of silica. It is estimated that there are 1,900,000 tons of ore, of which 480,000 tons can be quarried and the remainder won by adit mining. Area B is to the north of A, and is of similar formation, estimated to contain 6,600,000 tons, of which 1,400,000 tons is suitable for open-cast, 3,200,000 tons adit, and 2,000,000 tons underground. In the faulted portion 75,000 tons can be quarried and 225,000 tons won by adit mining. Area C to the south-west of the Police Camp is mostly siliceous, with some clay-band. The yield in the former is estimated at 19,000,000 tons, of which nearly half can be obtained by open-cast and adit mining. The percentage of metal ranges between 41·9 and 51·3, and the silica between 16·3 and 26·12. The clay-band is estimated to contain 1,250,000 tons of recoverable ore, with an additional 1,000,000 tons down to 300 ft. The iron content is 50·6 per cent. to 55 per cent., and the silica from 8·18 per cent. to 10·93 per cent. The first 2,000 tons quarried showed an average above 50 per cent. of iron. Area D, a narrow strip within C, is estimated to contain 250,000 tons of recoverable clay-band; whilst area E is estimated to yield only about 10,000 tons. The total yield, after allowing for pillars, faults and patches of low-grade, is therefore about 20,000,000 tons, averaging about 45 per cent. metal. The cost would probably run from 4*s.* to 12*s.* per ton.

The hematite ores in the Rustenburg district have been described by Messrs. A. L. Hall and C. J. N. Jourdan (*South African Journal of Industries*, 1919, II, 1118). These consist of three bands of solid hematite, 21 ft., 4 ft. and 17 ft. thick respectively, separated by layers of siliceous rock, and yielding on an average 63 per cent. iron. The ore is low in silica and phosphorus, and very suitable for the acid Bessemer process. As, however, it is situated about 75 miles from a railway, a line would have to be provided, and in that case open-cast mining could be carried on very cheaply, the estimated cost per ton, delivered in Pretoria, being about 8*s.* 9*d.*

There is a deposit of magnetite in the Ermelo district which was said to be capable of yielding 3,000 tons per month at 2*l.* per ton alongside steamer at Durban. It was offered to the Ministry of Munitions as being comparable with C 1 grade of Swedish ore, but chiefly owing to shipping difficulties the Ministry was unable to purchase. It was worked for a time up to February, 1918, by the Ermelo Coal and Iron Syndicate, Limited. Between 200,000 tons and 300,000 tons were practically in sight.

At Onderstepoort, 9 miles north of Pretoria, there are very extensive formations of titaniferous ore, around the edge of the Bushveld granite, estimated at not less than 24,000,000 tons at the surface. These have generally been regarded as commercially valueless, owing to the high titanium content and consequent difficulty in smelting. Professor Stanley, however, is strongly of opinion that, as a result of his experiments in 1909–10, fluxing could be readily carried out by using silica and lime. Stansfield and Wissler have since confirmed this (*Transactions of the Royal Society of Canada*, vol. x, 1916, pages 33–42), and state that such ores can be smelted without special difficulty by using silica as well as lime. Reference may well be made in this connection to a paper by J. A. Heskett on "Utilisation of Titaniferous Iron Ore in New Zealand," read before the Iron and Steel Institute on May 6, 1920, in which an apparently successful method of treatment is described (ENGINEERING, vol. cix, pp. 875–877. It is suggested that further research be undertaken with these ores, in view of the large amount available and the additional fact they have been found to contain vanadium, by Mr. J. K. Exter, of the Pretoria Iron Mines, Limited. Analysis by the South African Government chemist, Dr. McCrae, also revealed an appreciable percentage of vanadium (from 0·25 per cent. to 2·5 per cent.). By using charcoal as fuel a very high quality iron would be obtained, as the ore is practically free from sulphur and phosphorus. In the same neighbourhood there are also fairly extensive deposits of chromite, but they are about 40 miles from a railway. Samples assayed 40 per cent., 48·5 per cent. and 33·5 per cent. chromic oxide.

References are made in recent literature (*e.g.*, *Bull. Imp. Inst.*, 1920, vol. i, pages 90–91) to iron ore deposits in the Cape Province and in Natal, but they do not appear, at present, to be of any great value, except perhaps in the vicinity of Maritzburg, where the Dominions Royal Commission in 1913 reported large quantities of (1) hydrated sesquioxide, with 62 per cent. iron; (2) manganiferous hematite with 50 per cent. iron, probably capable of yielding millions of tons; and (3) brown hematite, with 35 per cent. iron. Professor Stanley concludes that there is a large quantity of good grade ore available in this district, within easy distance of railways, fuel, &c. (*South African Journal of Industries*, 1920, page 634).

Manganese is, of course, essential in modern steel-making, and the resources of South Africa in this direction appear, from the data available, to be fairly satisfactory. Professor Stanley (*loc. cit.*) states that, according to Mr. Bloom, of Johannesburg, one deposit alone would furnish 50,000 tons of ore, assaying from 20 per cent. to 60 per cent. MnO_2. But the most important are the latcroidal deposits associated with dolomite on farms in the Krugersdorp district, containing from 59 per cent. to 63 per cent. dioxide, whilst hard specimens contain as much as 92·5 per cent. Small occurrences have been found in the Vryheid district, Natal, but only of second rate quality. Those in the Cape Province were reported on in 1917 by Mr. Welsh, Assistant Inspector of Mines. Only one of these is really important and may contain up to 500,000 tons of ore. The exploitation of this would be very difficult as it forms the site of the Caledon hot springs and sanatorium.

As regards fuels, Sir Robert Kotze in 1911 ("Coal Resources of South Africa," *Report of the Geological Survey*, 1911), estimated the coal in the Transvaal at 36,000,000 tons, so that a good supply of coke ought to be obtainable. Professor Stanley carried out numerous experiments for Pretoria Iron Mines, Limited, and obtained some very satisfactory samples of coke, although perhaps not up to best British standards. He found that improvement in both ash and sulphur content could be effected by crushing to a smaller size than usual, say, to pass through a $\frac{1}{4}$-in. linear mesh screen.

In Natal the coal resources, according to the above-mentioned Geological Survey, 1911, are estimated at 9,400,000,000 tons, and good quality coke is already being made by several firms. Analyses by Professor Stanley showed that while the ash and sulphur are often rather high, the structure and strength are good. The recovery of by-products, tar, benzol, &c., could be greatly extended.

Charcoal could probably be used to some extent, and Mr. T. R. Sim, late Conservator of Forests (*Report of South African Association for Advancement of Science*, Maritzburg, 1916, pages 279–301) estimates that there are 160,000 acres under wattle and 200,000 tons of timber are annually burnt as waste. From these sources up to 40,000 tons of charcoal would be obtainable, and if afforestation is vigorously taken up, as the Government intends, and valuable by-products are obtained with the charcoal, there should be a large and progressive supply of valuable fuel for smelting purposes. According to Mr. J. S. Jamieson, in his presidential address to the South African Association of Analytical Chemists, a ton of wood should yield 627 lb. of charcoal, 3 gallons of methyl alcohol, 2 gallons of acetic acid and 44 lb. of pitch.

The prospects of a great development in South Africa's iron and steel industry seem favourable. It was begun on a small scale some years ago. In 1913 the Union Steel Corporation began work at Vereeniging, followed by the Dunswart Iron and Steel Works, and the Witwatersrand Co-operative Smelting Works. These works, however, did not use native ore but waste metal from the mines and railways. It was not until 1918 that pig iron was

produced from ore in the blast furnaces of the Pretoria Iron Mines, Limited, and the Transvaal Blast Furnace Company at Vereeniging. Some 2,000 tons of pig were produced up to the beginning of this year. A further important step forward, according to latest advices from South Africa (*The Times*, September 4, 1920) is the ratification of the agreements with the Pretoria Iron Mines (now forming part of the South African Iron and Steel Corporation) just signed by the Minister of Railways. According to this agreement it is stipulated that the South African Government shall purchase at least 50 per cent. of its requirements in rails, steel plates, &c., from the Pretoria Iron Mines, Limited, and various regulations as to the prices to be paid are laid down. In his evidence before a Select Committee the chairman of the company, Mr. Romyn, said that the property of the mines was 800 acres in extent, 3 miles from Pretoria. The surplus power and waste coal would be easily disposed of, and there would be good markets for by-products. The quantity of ore on the site is estimated now at 30,000,000 tons, containing 50 per cent. iron, and followed to depth the amount is practically unlimited. The best coal in South Africa is easily obtainable from the neighbouring Witbank coalfields.

NOTES.

A New Departure by a City Livery Company.

We gather from an announcement made at a dinner on Wednesday evening last of the Worshipful Company of Fan Makers that an interesting change in the scope of this old London company has recently been made. Hitherto the company has concerned itself mainly, if not entirely, with the arts and crafts involved in the design and manufacture of that type of fan usually associated with feminine coquetry. Now, however, it has been decided to include within its purview that type of fan with which the engineer is concerned in the professional side of his career. In pursuance of this policy, which we believe is largely due to the influence of Dr. S. Rideal, an "assistant" of the Fan Makers' Company, that body is offering a medal for the best essay on a subject in connection with the theory and practice of ventilation. The medal, in the first instance, will be competed for by students in the City of London and will be open to all London polytechnics and other colleges belonging to the City, but later it will be made possible for provincial students to compete. The arrangements for the award of the medal are, however, not yet completed, but the details are being considered by Principal Sidney Skinner, of the South-Western Polytechnic, Chelsea, S.W., and will be announced later. In conjunction with the Coal Smoke Abatement Society, which has been the primary mover in an endeavour to improve the condition of London by the abolition of black smoke from household chimneys, the Fan Makers' Company have also decided to promote an exhibition which will be held in London in February next for the purpose of testing smoke-consuming and ventilating appliances for improving the atmosphere in towns and factories. It is undoubtedly possible to effect a considerable economy in fuel consumption and also an improvement in the public health by such means, the importance of which is none too fully realised. The interest which the Institution of Heating and Ventilating Engineers has in the proposal of the Fan Makers' Company to enter the field of technical fan making was evidenced by the presence at the dinner of Mr. W. W. Nobbs, the president of the former body, and the fact that Dr. G. C. Simpson, C.B.E., F.R.S., the newly appointed Director of Meteorology at the Air Ministry was present, as well as the former Director Sir Napier Shaw, F.R.S., is an indication of official interest in the idea.

British Railway Electrification Standards.

The Electrification of Railways Advisory Committee, which was appointed by the Ministry of Transport to advise on the best system for future electrification in this country, has issued an interim report in which they recommend that 1,500 volts D.C. at the sub-station bus-bars shall be the future standard, and that departures from this, if it can be shown to the Ministry that they are desirable, shall involve the adoption either of half the standard voltage, or of multiples of it. The fixing of a system and a voltage for all our future railway electrification is not a matter which can be settled in an off-hand way, but even those who have not had an opportunity of studying the matter closely, or examining the data available, will, in general, be inclined to accept the Committee's recommendation as reasonable. This matter is one which cannot be settled on theoretical or purely engineering considerations, and much attention has naturally to be given to the complications introduced by existing electrified lines. No recommendations are made for the modification of existing 600 or 1,200-volt systems and their extension is to be allowed, while the Brighton single-phase system is similarly not to be interfered with, and it is recognised that special arrangements for the whole of the proposed South East group of railways may have to be considered later. It will be clear that the Report contains nothing very heroic, and that no policy of wholesale scrapping is in contemplation. This appears to us to be in accord with common sense, and with the present general financial condition of the country. It is very desirable that a standard for future work should be laid down, but it is very undesirable that costly attempts should at the present time be made in the direction of bringing existing plants into line. When the new standards have been established for some time, and are in use on a considerable scale, conveniences for interworking may suggest modification in some existing services. The system adopted as a standard will enable this to be done without radical reconstruction in the case of the majority of existing systems, while the voltage adopted allows of long stretches of line being dealt with economically and takes advantage of modern improvements in manufacture to cut-down conductor sections and so to reduce capital cost. The isolated case of the Brighton line does not come within these considerations, and it is possible that it may always remain an isolated case.

Oil Fuel on Passenger Ships.

The increasing adoption of oil fuel in passenger vessels raises questions of fire risk. Oil leakage may be a source of danger which is not present in ships burning coal, while internal damage due to collision or stranding may release the oil in considerable bulk with possibility of it becoming ignited. Vapour rising from oil stored in tanks may also conceivably become a source of fire danger. In view of these considerations, the Board of Trade appointed a Committee last January to enquire into the matter. Its report has just been published, and a number of recommendations made, which in view of the authoritative nature of the Committee one may anticipate will be adopted by the Board. Among the more important of these it is suggested that a sample of each supply of fuel oil taken on board a vessel shall be tested by the chief engineer to see that its flash point is not below 150° F. The test is a simple one and can be carried out with an apparatus which has already been sanctioned by the Board of Trade. It is proposed that it shall be allowable to carry oil in cellular double bottoms under engine and boiler compartments and in peak tanks, deep tanks and bunkers. Consideration should, however, be given to the avoidance, as far as possible, of oil fuel bunkers in 'tween decks space overhanging boiler rooms, or of oil-fuel bunkers adjoining the ships' sides abreast of the boiler rooms. Where these are found to be necessary, they must be sub-divided into compartments not exceeding 21 ft. in length. To prevent the spread of fire which might follow on a collision or grounding in way of oil-fuel bunkers, it is proposed that the boiler and funnel casings should be so insulated, and all doors and other openings so arranged that the heat from even a fierce fire would not endanger surrounding woodwork, or accommodation. Further points deal with the leading of air pipes to an open situation, the testing of storage tanks, &c. The Committee's investigations indicated that the chief cause of fire had proved to be leakage from flanged joints in the pressure system conveying heated oil to the boilers, and accordingly solid-drawn steel pipes are recommended with machined flanges coupled practically metal to metal. Any jointing material used should be the thinnest possible, and impervious to oil heated to 250° F. The scantlings of flanges should be suitable for a working pressure of 200 lbs. per square inch, and all pipes, fittings, &c., should be tested to double working pressure or at least 400 lbs. after jointing. Other recommendations in connection with lighting, ventilation, &c., we need not refer to in detail. It will be gathered that this expert Committee is satisfied that no drastic measures are necessary to meet the fire risk on such oil-burning passenger ships. Their recommendations can, in general, be carried out without difficulty, and as we have said, one may expect to see them adopted officially.

The Port of London.

Although the figure for the total net tonnage of vessels arriving at, and departing from, the Port of London during 1919, shows a considerable improvement on that for the preceding year, it still falls far below the corresponding figures for the years immediately prior to the war. In 1913, the last year of trade entirely unaffected by the war, the net tonnage arriving and departing amounted to 40,082,282, whereas for 1919, the first complete year after the termination of hostilities, the figure was 26,335,191 tons, or rather less than 66 per cent. of the pre-war figure. Last year, however, as might be expected, showed a considerable improvement over the previous year, in which the low-water mark of 14,564,008 tons was reached, this latter figure being little more than 36 per cent. of that for 1913. For the other war years the figures were 37,154,133 tons for 1914, 30,890,531 tons for 1915, 24,976,437 tons for 1916, and 18,053,002 tons for 1917, each of which, it will be noticed, shows a diminution of some 6,000,000 tons on the preceding year. These figures, it should be stated, by no means accurately represent the activity of the Port of London during the war, since the tonnages of many vessels using the Port on Government service are not included. The total value of the goods imported or exported from the Port of London last year amounted to nearly 820,000,000*l.* which is about 31.7 per cent. of the whole overseas trade of the United Kingdom, and is only slightly less than the import and export trade of Liverpool. For the latter port, the value of the goods handled in 1919 amounted to nearly 828,000,000*l.*, or about 32 per cent. of that for the whole country. The figure for London shows an increase of 51.3 per cent. on that for 1918, while, for Liverpool, the increase is only 21.2 per cent. The foregoing figures have been taken from the Report of the Port of London Authority for the year ended March 31 last, in which period the Authority landed, or received 2,699,181 tons of import goods, and also handled 737,783 tons of goods for export. The imports show an increase of 19.8 per cent. in comparison with the previous year, and the exports an increase of but little more than 9 per cent. The stocks in the warehouses directly controlled by the Authority at the end of last March amounted to 784,608 tons, as compared with 705,323 tons at the end of March, 1919, the difference of 79,285 tons representing an increase of over 11 per cent. In this connection the report states that the demand for storage space has been unprecedented owing to the fact that shipments under forward contracts for certain articles such as tea, wool, and meat were made without regard to the rate at which they were able to pass into consumption. To meet this demand the Authority has provided additional storage space, amounting in all to 2,500,000 sq. ft., of which about 800,000 sq. ft. were added during the year to which the report refers. The shortage of railway trucks, barges and road wagons has made the problem of distribution extremely difficult ever since the outbreak of war, and although at the height of the recent congestion period, about a year ago, some measure of relief was obtained by the employment of Government motor lorries, the report states that this method of transport was found to be costly. Various measures adopted by the Authority have however, materially reduced the congestion, and although it cannot yet be stated with certainty that there will be no recurrence of the trouble, it appears that the time required for the turning round of ships is now approaching the normal.

THE ROYAL AGRICULTURAL SOCIETY'S TRIALS OF AGRICULTURAL TRACTORS AND PLOUGHS.

(*Concluded from page* 451.)

On Thursday, the 30th ult. and Friday, the 1st inst., the trials were continued on the heavy land, classes 2 and 5 doing their heavy ploughing on Thursday and classes 1, 3, 4, 6 and 7 on Friday. Class 5 apparently did not finish on Thursday, and completed their ploughing on Friday. There is no doubt that this test really tried the pulling power of the various machines, for the land was in the main very stiff clay indeed, and very dry and hard. The fact that it was dry, however, gave no indication of what the performances would be in soft ground. On Friday the ground was less favourable than on Thursday, as there had been some rain in the night which made the surface somewhat greasy without softening the land. Practically all the machines completed the work given them.

Taking the various classes, those for steam engines only produced one entry in each class. These appeared to perform quite satisfactorily, the Fowler double engine set pulling a five-furrow plough and the Mann steam tractor a four-furrow. While the performances of the steam sets were excellent and the future use of steam may still be very large, there was little of novelty in them, and more interest attached to the work done by the oil engines.

The Fowler and McLaren double engine sets with oil engines formed an interesting comparison. The Fowler plant is, roughly speaking, twice the weight, and is rated at nearly twice the power of the McLaren. In the light land the Fowler set was using a five-furrow plough and the McLaren a four-furrow, and there did not appear to be a great deal of difference in the speed of ploughing. It appeared, therefore, that to give a performance proportionate to its weight and power the Fowler set should have ploughed more furrows, which it could probably quite well have done. The field in which the "heavy" trials took place was good stiff clay, and here the Fowler was using the five-furrow plough as before, but the McLaren was only using a three-furrow. Both engines were performing satisfactorily, and when results are published it will probably be found that the work done was much in proportion to their rated powers. Incidentally it may be mentioned that although the Fowler steam set is called "8 horse-power," it was doing the same work as the petrol set whose engine will develop 60 h.p. This shows what an arbitrary thing "nominal horse-power" is, and as agricultural oil engines are rated at their actual horse-power, it seems as if steam engines should be dealt with in the same way.

The most interesting class was class 2, for tractors under 30 h.p. Unfortunately it was not possible to have all the heavy land tests for this class in the same field owing to the great number of competitors. They were, therefore, divided among three fields. As it happened one of these fields was of very stiff clay indeed, while the others, though heavy, were not so tenacious. A few of the lighter of the tractors found some difficulty in pulling the three-furrow plough in the extremely stiff clay, but the large majority succeeded satisfactorily. In consequence of the difference in the nature of the ground the trial grounds were changed at lunch time, those machines which had been in the very heavy ground being put into lighter, and *vice versa*. Eventually nearly all the machines finished the work allotted to them, but in practice it seems hardly likely that the lighter of those entered in this class would be used for three-furrow ploughs in land of this nature, though on light land they would do well with this number of furrows.

The annexed table gives the weights of the machines in the different classes arranged in order of the stated weights, and it will be seen that a few of the machines in class 2 are lighter than the majority of those in class 1, which only have to do two-thirds the work of class 2 tractors. It suggests a sanguine temperament to have entered these in class 2, and it is not to be wondered at that the machines had trouble in the heavy land, for it was the lighter machines that found difficulty. It appears to have been realised by the entrants of the three lightest machines in class 2 that they might be more suitable for class 1 as an apparently duplicate machine is entered in class 1 in each case.

Class 1 tractors under 24 h.p., pulling two-furrow ploughs, had more greasy ground than class 2, as it rained on Thursday night. This did not, however, prevent their performing well, generally speaking, and the same may be said of class 7 (self-contained ploughs). Of these No. 33 (Moline) and No. 15 (Crawley) were ploughing three furrows, and going well. The former seemed ploughing particularly fast. No. 22 (Fowler), No. 30 (Martin) and No. 38 (Ruston Proctor) were ploughing two furrows.

Table of Weights of Tractors.

No.	Makers.	Weight in Lb.
	Class 1.	
19	Ford	2,515
42	Saunderson	3,024
5	Austin	3,136
3	Ancona (British Wallis)	3,360
24	General Motors	3,400
10	Burford (Cleveland)	3,472
12	Case	3,918
23	Garne	4,032
40	Saunderson	6,160
	Class 2.	
6	Austin	3,136
4	Ancona (British Wallis)	3,360
11	Burford (Cleveland)	3,472
46	Weeks	3,920
34	Noyes (Stockwell)	4,200
45	Wallace ("Glasgow")	4,400
37	Pick	4,480
16	Fairbanks Morse (Twin City)	4,500
32	Melchia	4,900
36	Brotherhood	5,000
43	Simpson	5,000
8	Blackstone	5,040
2	Agricultural Wholesale (Hart Pan)	5,376
9	Pavesi	5,500
1	Agri Tractor (Pavett)	5,515
14	Chase	5,600
29	Martin	5,824
13	Case	5,916
41	Saunderson	6,160
17	F.I.A.T.	6,384
	Class 3.	
18	F.I.A.T.	6,384
27	Lauson	6,925
7	Berna	7,273
	Class 4.	
28	Mann	10,752
	Class 5.	
20	Fowler (each engine)	14,560
32	McLaren	7,280
	Class 6.	
21	Fowler	27,440
	Class 7.	
22	Fowler	3,360
33	Motive (Moline)	4,256
30	Martin	4,480
15	Crawley	4,704
39	Santler	5,376
38	Ransome	5,824

On Saturday, October 2, a few machines in class 1 and 2 were given supplementary trials, the purpose of which did not transpire. Class 7 also was tested in "cultivating." It had rained heavily the night before, which made the ground soft and sticky, but generally speaking the tractors tried pulled their ploughs satisfactorily. Those tried included: Class 1, No. 5 (Austin), No. 3 (British Wallis), No. 12 (Case), and No. 19 (Ford). Class 2, No. 2 (Hart Parr), No. 4 (British Wallis), No. 13 (Case), No. 16 (Twin City), No. 36 (Brotherhood).

The margin of adhesion in the lighter machines seemed very small, but still the ploughs were pulled satisfactorily. A point of interest is the great diversity of spuds employed in the different competitions. These fall into three main divisions:—

1. Those which consist of angle irons right across the wheels, usually at a considerable angle.

2. The same as 1, but with the angle irons projecting some distance beyond the wheel.

3. Spuds much narrower than the wheel placed in two or more rows. These are usually square across the wheel.

So far as the ground dealt with has gone, all these seemed successful, and there is not enough data for good comparisons. It appears, however, to be a matter well worth investigating, as there may be a considerable variation, both in the holding power and also in the resistance. To judge at all accurately of the different efficiencies, it would be necessary to know the draw-bar pull the wheel will develop without slipping, and the actual weight on the axle, and these figures are not available.

The usual method of using a tractor when ploughing is for one driving wheel to run in the furrow and the other on the unploughed land. When spuds projecting beyond the wheels are employed, these can only be put on the wheel not running in the furrow. Generally speaking it appeared that the wheel in the furrow was most liable to slip, and therefore the utility of the extension spuds seems doubtful unless a differential lock is used.

As far as could be seen the short spuds in more than one row appeared to be slightly more effective than the angle irons right across and did not appear to be quite so liable to clog up on the sticky ground after the rain. This point may be of some importance, as some of the driving wheels gathered quite a lot of clay round them which decreased the effective depth of the spuds and also raised the tractor a inch or more off the ground, so raising the plough attachment. It is an undoubted advantage of the caterpillar type of machine that the track does not gather mud in this way.

Another point of interest is what cross-section the spuds should be. For constructive reasons those going right across the wheel were parallel, being usually made of ordinary angle iron, while the short spuds were usually much thicker at the root than the point. As the flanks of the former are radial to the wheel they tend to tear up the ground more than the latter.

Theoretically the flanks of the spuds ought probably to be curved like the flank of the teeth in an involute gear wheel. The spuds of one machine were curved more or less in this manner and appeared to hold exceptionally well, and not to tear up the ground or collect mud as much as most others. It is rather curious that all spuds appear to be straight on the driving side in horizontal section. All the angle iron spuds are straight, and the short spuds are also straight, and both usually have sharp corners and edges. In other similar circumstances it has often been found desirable to have other contours. The spuds in the Holt caterpillar are V-shaped, driving from the convex side. Theoretically curved spuds driving from the converse side should be more efficient than straight ones, and further theoretically, the edges should not be sharp, but rounded, as a sharp edge shears the ground more easily than a blunt one.

Another point of interest is the position of the wheels of the tractor on the ground. It is the usual practice for the left-hand wheel to run in the furrow. In the "Case" tractor both wheels run on the unploughed land, and this has some distinct advantages. It is probable that the resistance is considerably less on the unploughed land than in the furrow, and the adhesion will usually be better, while, if desired, spuds projecting beyond the wheels can be employed on both wheels. It is also possible that the wheel running in the furrow may consolidate the subsoil to a greater extent than the wheel on the unploughed land, and therefore do damage to the land.

On Monday, the 4th inst., various machines were tested in ploughing on hilly ground. In this practically all were successful, though one or two of the self-contained ploughs had some trouble through the wheel slipping. The steepness of the gradient varied very considerably in different parts of the field chosen, and it appeared only to be those machines which had the steepest bits to plough which had any difficulty. Dynamometer tests in the heavy land were continued.

On Tuesday, the 5th, circle turning tests were made in the morning. The majority of tractors will turn in quite a small circle, but doubtless exact figures will be given in the report. In the afternoon the tractors were tested up a hill on the road, pulling a gross load of four tons. The gradient looked about one in ten, and the surface was good. On this test a considerable proportion of the machines failed. This is hardly to be wondered at in the case of the lighter machines, for it naturally follows that a four-ton load is a much more severe test for a tractor weighing 2,500 lbs. than it is for one weighing over 6,000 lbs.

Failure appeared to be invariably due to the wheels slipping and not to want of power. This being so, the only factor in success was the weight on the driving wheels and the nature of the wheel.

The latter varied considerably. A good many competitors made no preparation for such a test, and had quite smooth wheels, which naturally slipped easily. Bars across the wheels like a traction engine were better, but they still slipped badly in several instances. The British Wallis had wood covering to the wheels, and this appeared to hold very well, considering the weight of the machine. The Brotherhood and Garner had rubber treads fixed on the wheels, and went up well. The Cleveland went up well, and it appears that the track holds a good deal better for its weight than the wheel. Few competitors locked their differential and many would probably have done better if they had.

So far as could be seen the trials were very well organised for the purpose of testing the machines, but it would have made them of greater interest if it had been a little easier to get information as to what was going on and as to general details. Doubtless there were difficulties in combining the two.

One point which should receive attention another time is the description of the various machines in the catalogue. The actual names, by which the vehicles are generally known, are in many cases not given at all, the only name mentioned being that of the firm, often an agent, who enters them. Thus such names as "British Wallis," "G.O.", "Cleveland," &c., are not to be found in the catalogue at all, but only the names of the firms entering them. It would also add interest if the names of absentees and notices of breakdowns were posted up in some really conspicuous place.

It appears that the following machines failed to put in an appearance:—

No. 9.	Pavesi.
No. 25.	International Harvester.
No. 26.	International Harvester.
No. 35.	Overtime.
No. 40.	Saunderson.
No. 43.	Simpson-Moseley.
No. 44.	Timesaver.

No. 18, F.I.A.T., appeared, but did not compete, and No. 37 (Pick) and No. 39 (Santler) withdrew during the competitions. We await the judges' report before making further comment on this competition. So far the trials have demonstrated that the majority of the machines entered will do their work satisfactorily, and the main points of interest will be the fuel and oil consumptions, &c.

The Institution of Automobile Engineers.—We understand that the Society of Motor Manufacturers and Traders have extended to all members of the Institution the privilege of visiting Olympia on the private view days to inspect the exhibits at the forthcoming Commercial Vehicle Show and Motor Car Show. The private view day for the former exhibition is Thursday, October 14, and for the latter, Thursday, November 4. Members wishing to take advantage of these offers should apply to the Secretary of the Institution of Automobile Engineers for tickets, but it should be noted that the invitations are extended to members only and do not include friends. The first annual dinner of the Institution will be held at the Royal Automobile Club on Wednesday, the 27th inst., at 7.30 p.m. The largest number of applications for admission to the Institution was considered by the council at their last meeting, forms for over 70 members and associate members, and nearly 50 graduates, having been submitted.

British Standard Specification for Portland Cement.—In accordance with the established practice of the British Engineering Standards Association, the British standard specification for Portland cement, which was first issued in 1904, has been revised from time to time in order to keep it abreast of the progress in manufacture and the requirements of engineers and architects. The new edition, just issued, supersedes that published in 1915, and has been rendered necessary owing to improvements made and experience gained since that time, and also by the altered conditions of storage now coming into existence. Among the modifications we notice that it is now definitely stated that no cement to which slag has been added, or which is a mixture of Portland cement and slag, will comply with the specification, and also that the specific-gravity test and the aeration of cement before testing for setting time, have both been eliminated. Other modifications refer to the sampling of cement stored in deep silos, the calculation of the lime ratio, setting times, and the supply of certificates by the vendor. The specification, the price of which is 1s. net or 1s. 2d. post free, can be obtained through any bookseller or directly from the offices of the Association, at 28, Victoria-street, London, S.W. 1. It is published for the Association by Messrs. Crosby Lockwood and Son, 7, Stationers' Hall Court, London, E.C. 4.

INDUSTRIAL NOTES.

The Secretary of the Department of Scientific and Industrial Research announces that a licence has been issued by the Board of Trade to the British Electrical and Allied Industries Research Association, which has been approved by the department as complying with the conditions laid down in the Government scheme for encouragement of industrial research. The association may be approached through Mr. E. B. Wedmore, Electrical Research Committee, care of Electrical Development Association, Hampden House, 64, Kingsway, W.C. 2.

New housing schemes submitted to the Ministry during the week ended September 25, numbered 44, bringing the total number of schemes submitted to 11,139, comprising about 74,000 acres. The schemes approved now number 8,105, and comprise about 54,329 acres. Seventy-seven lay-out schemes were submitted, and 45 approved during the week, bringing the total number of lay-outs submitted to 6,205, and the number approved to 5,587. House plans representing 2,106 houses were submitted, and plans for 2,812 houses approved. The total number of houses represented in all the plans now submitted is 259,972, and in the plans approved 244,472. During the week tenders were submitted for 3,479 houses. Tenders for 1,835 were approved, bringing the total number of houses in tenders submitted to 159,969, and in tenders approved to 144,789. Contracts have been signed for 106,902 houses. Up to the beginning of September only 60 per cent. of the skilled labour required for housing schemes was available. The number of men employed was 22,397, the number needed was 37,132, leaving a deficiency of 14,735. This deficiency was made up as follows: 8,218 bricklayers, 3,785 carpenters, 651 slaters and tilers, 1,127 plasterers, 487 plumbers and 467 painters and glaziers. With the exception of the last two trades, these figures represent an increase in the numbers required in every case, over those notified last month. The number of houses in respect of which certificate "A" has been issued to private builders, has now passed the 20,000 mark, the total figure being 20,308. Payments have been made in respect of 1,753 completed houses.

The most important industrial problem now before the public still continues to be the threatened coal strike. Whilst bad management does undoubtedly reduce output, and naturally, during the period of government control, average efficiency must have tended to deteriorate, this is not the main factor in the serious falling off in the productivity of our mines. Past experience, not only in the coal trade, but in some other highly-paid industries, has shown that the higher the pay the less the weekly output is likely to be. This rule was found to hold with regard to the last increase in miners' wages, a circumstance which is difficult to reconcile with the prevalent theory that the cost of living to the miner has increased by over 160 per cent. The general experience is, that when men have for one reason or another a difficulty in making both ends meet, they are very regular in attendance at their work, but this has certainly not been the experience in the coal trade. No doubt the term "cost of living" is a very ambiguous one, as is the term "living wage." The latter is commonly used in two entirely distinct senses. In making an appeal for public sympathy an orator endeavours to convey the impression that by living wage is implied a sum just sufficient to keep body and soul together. Obviously no industry could be conducted in which wages fell below this limit, and a cross-examination of those who expatiate on the necessity of the "living wage" invariably shows that what is in view is not a "living wage," about the necessity of which there can arise no difference of opinion, but a "fair wage," the amount of which naturally varies with circumstances.

To meet the very real danger that increased pay will mean less coal won, the Government have proposed that a sliding scale should be adopted, according to which rates of pay would automatically increase with output. The men demanded an immediate increase of 2s. per shift irrespective of output, but finally agreed to meet the coal owners and endeavour to arrange a sliding scale in accordance with the suggestion above referred to. It appeared, however, that in the first instance, the miners simply saw in this a chance for obtaining forthwith the 2s. a shift without any increase of output, a demand which, if granted, would almost certainly have led to greater absenteeism. Ultimately, however, a provisional agreement was reached by which 1s. a shift is conceded if the output is at the rate of 240,000,000 tons per annum, a level which it is thought is now obtained, and there is to be a further increase of 6d. for each increase of 4,000,000 tons in the annual output, so that with an output of 256,000,000 tons the gain will be 3s. per shift. This agreement has to be ratified by the men, the threatened strike being postponed for a fortnight for the purpose of a ballot. The proposal is meeting with strenuous opposition in South Wales and Lancashire. In the former district the men's main grievance seems to be not that they are badly off (indeed, official figures show the average earnings, inclusive of men and boys, to be over 226*l.* per annum), but that certain men of genius have made fortunes in the coal trade. It was Andrew Carnegie who once observed that in the country where millionaires were impossible the "common people" were generally badly off. This view is certainly confirmed by the failure of the co-operative societies to develop a single new industry, or introduce any improvement of fundamental importance into manufacturing operations. Capital they can provide, and labour they can obtain, but they have found it impossible to replace the capitalist, whose methods they copy from afar, but they are unable to copy his mind.

It is gratifying to note that the Amalgamated Engineering Trades Union and the Employers' Federation have prepared a draft agreement which is now to be submitted for ratification by the respective organisations. The agreement deals mainly with night shifts and overtime, for which some managers have in the past had an unreasonable and probably misguided predilection. Even where unavoidable, great lack of consideration has often been shown by failure to give the men concerned timely notice. In the past a man has frequently been asked to work overtime late in the afternoon, when he has no opportunity of making arrangements for a meal, and the management have on their part taken no steps to fill the void. Under the draft agreement, which is to apply generally and not merely locally, the rate for overtime is to be "time and a half" for all overtime up to midnight, and double time for each hour worked after this. There are, moreover, certain additional allowances for men who work past midnight but are sent home before 6 a.m. Thus if a day-shift man is sent home between midnight and 2 a.m., he will get not only double time for the hours worked after midnight, but also time and a half for the hours between the time when he is sent home and 6 a.m. If he is sent home after 2 a.m., he will get double time for the hours worked after midnight, and in addition an allowance of double time for the hours between the time when he is sent home and 6 a.m. Work between Saturday midnight and Sunday midnight must in all cases be paid for at the double time rate. Except in special cases, such as repairs, breakdowns, and completion of contracts to time, overtime is to be limited to a maximum of 30 hours per month, and all systematic overtime is to be discouraged by both parties to the agreement. The working week for the night shift is to be 47 hours and the rate of pay time and one-third. Work done between Saturday midnight and Sunday midnight will be paid for at double time rates, and other work on Saturday and Sunday nights at the rate of time and two-thirds.

Trade prospects throughout the country appear somewhat gloomy. At Sheffield Messrs. Steel, Peach and Tozer have given notice to no less than 1,000 of their men, and there is an alarming increase of unemployment in the Black Country, whilst stoppages are increasing in North and North-East Lancashire. At Coventry, again, many discharges are reported, whilst at Lincoln Messrs. Ruston and Hornsby are suspending the remaining 400 of their employees till October 12th. At Sunderland 500 women and girls have been discharged from Messrs. Craven and Speedings' rope works owing to excessive costs of production and consequent lack of orders.

For this state of things there would appear to be only one remedy. The labour cost of all manufactured goods constitutes the bulk of the cost, and must be reduced. The usual crude method of accomplishing this is to reduce wages—a method that requires the least intelligence in its application, but creates the greatest friction. The alternative is to improve methods so as to increase output whilst maintaining the weekly takings of the operatives at their present high figure. Mr. Ford has shown what is possible in this way, as even prior to the war the minimum pay for an adult in his factories was 1*l.* a day. Unfortunately, however, the introduction here of improved methods of manufacture occasions often nearly as much friction as does a cut in the weekly takings of the men. If the co-operation of the latter could be secured our immediate industrial prospects would be materially lightened.

The United Vehicle Workers are threatening a strike, which will, it is said, affect 200,000 men. The demand made is for a minimum wage of 4*l.* 7*s.* and a 48-hour week. On the other hand, the National Federation of the Vehicle Trades is threatening a

general lock-out in order to enforce the principle of payment by results, the industry being most adversely affected by current high prices. Negotiations have, however, assumed a favourable turn.

The Ministry of Health has just issued its first annual report. In the section devoted to proceedings under the Unemployed Workmen Act, it states that from the end of the winter 1914–15 till the commencement of demobilisation there was practically no distress arising from unemployment, and that the work of the Distress Committees was accordingly almost at a standstill. Ever since demobilisation commenced the grant of unemployment donation so far met the requirements as to render the provision of relief work unnecessary. The total expenditure under the Act for the year 1918–19 was 29,285*l.*, of which 22,602*l.* was expended on farm colonies and 4,497*l.* on salaries and establishment charges. Of the 94 Distress Committees existing in the provinces, 53 had found it unnecessary to keep accounts, and of the remainder only 3 had an expenditure exceeding 100*l.*

The committee on the re-employment of ex-service men has issued a preliminary report, in which it is stated that rather over 5,000,000 men have returned to civil life. At the beginning of April last about 220,000 ex-service men were drawing out-of-work donation, and this figure had been reduced to 156,000 by July 9. The majority of those still unemployed belong to large towns, a state of affairs which was paralleled in the Napoleonic era, where it was found much more easy to reabsorb into civilian work the peasants and agricultural labourers, than the town's people. A large number of those still unemployed are unskilled men of between 19 and 25 years of age. In general, employers are said to have fulfilled their obligations in regard to the reinstatement of ex-service men, although there are exceptions, more especially in the retail trades where male shop assistants have been to a considerable extent replaced by females. The trade unions are said to have helped in securing reinstatement of ex-service men and been willing in general to co-operate in opening new avenues of employment to disabled men. In some cases in which this co-operation has been lacking, negotiations are in progress. Certain trades, however, are said to have been unreasonable in the restrictions they have placed on the training of disabled men, amongst the lagging unions being those controlling the furnishing trades, the sheet metal trades, and the Operative Bricklayers' Society at Bristol is noted as having declined to put into operation the training scheme agreed to by their own executive. As regards non-disabled men, there is said to be room for these in the building trades, and also in the metal moulding trade, where the shortness of men is so serious that firms are compelled to import castings from abroad which ought to be made at home.

Owing to the unsettled conditions in this country the Glasgow Corporation has found it necessary to buy large quantities of rails in America. Last year 5,000 tons of rails were bought from the United States at a cost of 17*l.* 8*s.* landed at Glasgow. The lowest British offer was 19*l.* 1*s.* 3*d.* per ton, and was not a firm offer, as the contract contained a clause providing for an increase in price if labour costs went up. This year 10,000 tons have been required. The British price was 28*l.* per ton and the American 24*l.* 10*s.* per ton. Moreover, it is stated that the Americans deliver on time, whilst in the case of a British contract made before 1919, the rails have not yet been received. Incidentally it may be noted that though the system of internal transport adopted in Glasgow is inefficient according to the best modern standards, and the obstruction of the streets great, the fares have hitherto been low. It has now, it appears, been necessary to raise them in order to meet the demands of the men for higher pay.

An engineering works to be staffed and operated by women is to be opened near Loughborough. The promoters are most wisely starting on a very small scale in the hope of growing gradually to bigger things as experience is gained. About a dozen women will be employed at the outset. In this connection it is interesting to note that the great works of Brown, Boveri and Co., now employing many thousand hands, were originally opened with a total staff of 16. The women's works have already secured an order for hosiery needles and for machining parts of a new type of pump. It is hoped to develop the works on a co-partnership basis, but the first consideration will be to make the business pay, an aspiration which, if the works are to grow rapidly, almost inevitably involves autocratic control.

" The shipwrights' strike on the Mersey has now lasted five weeks, and the ship repair yards are being gradually brought to a standstill. Much work is in consequence being sent abroad, where some of the yards are now running three shifts. Including allied trades affected, the number of men rendered idle by the strike is said to total nearly 10,000.

Details of Mr. Bevin's extraordinary proposal by which registered dock labourers are to be guaranteed 4*l.* a week for doing nothing, have now been published. All apparently that a man has to do to qualify for this bonus is to present himself daily at the docks and ask for work. The funds for this charity are to be provided by a levy of 4*d.* per ton on all exports and imports. In this connection it should be remembered that the basis of the very high rate of 16*s.* per day which the dockers now receive, was granted largely on representations that the work was casual in character, involving many intervals of unemployment, and that therefore a higher daily rate of pay was necessary than in other trades where the conditions were more stable. It will be seen that this plea having served its purpose is now frankly abandoned, and the rate which was given so as to afford the worker an opportunity of making provision for unemployment is to be paid to him whether he be employed or not. Such a preposterous proposal stands little chance of acceptance.

The annual report of the Chief Inspector of Factories and Workshops for the year 1919 states that the number of factories has increased by 12,396 since 1914, and the number of workshops has decreased by 8,060, leaving a net increase of 4,336. Fatal accidents increased from 1,287 in 1914 to 1,385 in 1919. The reports received from inspectors show that the shortening of the working hours has had a beneficial effect on the operatives, perhaps more so than any other recent improvement in industrial conditions. "The old system of long, dreary, monotonous toil is rapidly giving way to a new system of reasonable hours, so that soon it may be hoped that the overworked man or woman in the industrial world will rarely be found. On all sides workers are securing by their own efforts shorter hours, and many letters are received asking whether periods well within those allowed under the Factory Acts are legal." Better timekeeping has resulted from the discontinuing of work before breakfast, and there have been less frequent absences owing to sickness. In one large factory where some years ago the average number of absentees was 40 daily, since the adoption of the 44-hours per week the average had dropped to 10 daily. As to the effect of these shorter hours on production the report states that when the production depends almost entirely on the speed of machinery—as in cotton or woollen spinning—the output is said to be reduced in a proportion nearly, if not fully, corresponding to the reduction in hours. In other machine operations which call for constant alertness on the part of the operator (*e.g.*, weaving) output had not suffered to this extent, and, in exceptional cases, had scarcely been affected at all. In a third class of process, where output was largely or entirely dependent upon the exertion of the worker, there was frequently no loss in production; indeed, in one wholesale tailoring establishment an increase of 40 per cent. was reported (partly due to reorganisation); while in a boot factory, where the hours of work were reduced from 52 to 48 per week, there was a considerable increase in output. Unfortunately a few of the reports indicate an extremely unfavourable result in some works, where the shortening of hours had been followed by a reduction in the hourly rate of production, and for this result no adequate explanation has, as a rule, been given.

NOTES ON NEW BOOKS.

Professors and their students are apt to undervalue the utility of elementary text-books, which will be insufficient for their own objects, and they have a right to do so. Such books, which should be written by the best men with a wide comprehensive grasp of scientific problems, are frequently compiled by people whose knowledge is quite inadequate to meet the requirements. But there must be elementary text-books for the people, who wish to learn but cannot profitably attend college lectures, and if these volumes are the outcome of lectures, delivered for some years to evening-class students, the kind of learners for whom the author writes, the volume may generally be acceptable. That will be allowed to the "*Elements of Electro-Technics*," by Mr. A. P. Young, O.B.E., M.I.E.E. [London: 350 pages, small octavo; Sir Isaac Pitman & Sons, Limited, 7*s.* 6*d.* net, bound]. It is quite commendable that Mr. Young has, for the sake of clearness, retained the style of the lecturer. Yet we do not see what clearness is gained by statements such as: "Electricity is the wonder of the Age." "Little progress was made in the development of the science after the discovery of Thales, 600 B.C., until 1600 A.D." Some of the very brief notes on the metallurgy of iron, &c., make one look somewhat suspiciously on the many good diagrams which one finds insufficiently explained. One is hardly prepared, moreover, for the practical exclusion of alternating current phenomena, which constitutes a serious drawback.

The British business connections with Spain, and the British imports from that country which interest our readers more especially, namely, imports of Spanish metallurgical products, are extensive, and a year book to facilitate business will be found welcome. A book of this class is the "*Anuario de Minería, Metalurgia, Electricidad y demas Industrias de España*," which is published at the price of 8·50 pesetas, by the well-known journal *Revista Minera*, Villalar 3, apartado 260, Madrid. It not only deals, as will be seen by its title, with the mining industries of the country, but gives information also on the metallurgical works, the electric installations and various other industrial undertakings. The present is the twentieth annual edition. Apart from a directory of the engineers and metallurgists residing in Spain, the book contains interesting information on the capital, the Board, and on the work dealt with by each mining and industrial company; the fees charged by the laboratory of the School of Mines for analysing ore; the laws and regulations relating to mining and industry, &c. Some particulars would, however, require revising; we find, for example, under the title "Orconera Iron Ore Company, Limited," the names of Sir David Dale, Bart., and of Mr. E. P. Martin, who died several years ago.

It is doubtful whether the "*Elements of Radio-telegraphy*" can adequately be explained in the 267 small pages of the volume of that title by Ellery W. Stone, of the United States' radio station at San Diego, California. But the book (London: Crosby, Lockwood and Son, 16*s.* 6*d.* net, bound), primarily written for the guidance of radio students in the Communication Service of the Navy, appears to be quite serviceable for that purpose. Yet one wonders a little to find the name of Hertz introduced after that of Marconi, by the statement that Marconi's greatest contribution to the art was the adoption of the grounded antenna, Hertz having previously employed ungrounded waves. One would have expected that the commendable introductory chapters on wave motion would have led up to the fundamental experiments of Hertz; but the reader is instead switched over to electric terms. The sequence of the chief systems, Marconi, Telefunken, Kilbourne and Clark, Haller-Cunningham, Fessenden, &c., is also odd, and though Lodge's work is duly recognised, Muirhead and Branly are never mentioned. The author rightly pays chief attention to apparatus actually in use; from that standpoint, however, the 20 pages of the last chapter on thermoionic valves [that term is not used at all, by the way] are hardly sufficient. The volume is well illustrated.

Engineering Supplies for Australia.—The Department of Overseas Trade is in receipt of a communication from the Manufacturing Engineers' Association of Australia, Melbourne, to the effect that they are interested in particulars of machine tools, drills, cutting wheels and milling cutters, and all manufacturing engineers' stores and supplies. They would value copies of United Kingdom manufacturers' catalogues, together with prices of machinery required in the equipment of factories. Such catalogues, which should be forwarded direct to the Association, would be included amongst the books in the library of the Association, where they would be available for reference by members. The members of the Association would be glad to co-operate in plans for facilitating intercourse between manufacturers' representatives from the United Kingdom, who may be visiting Australia. Such a scheme would afford United Kingdom manufacturers an opportunity of introducing their lines to the notice of purchasers under the best conditions, and it would afford engineers in Australia an opportunity of becoming acquainted with the latest manufacturing methods and appliances.

Engineers, Iron, Metal and Electrical Trades' Directory.—A copy of the fourteenth edition of this most useful work, which made its first appearance in 1870, has recently come to hand from the publishers, Messrs. Kelly's Directories, Limited, 182, High Holborn, W.C. 1. The well-known features of this directory include lists of firms engaged in all the various trades connected with every kind of metal, or having any relation to engineering work, in all parts of the United Kingdom. The first section gives every ascertainable name in the towns and villages arranged alphabetically under each county, and in the next section, which is devoted to the London district, the names are arranged alphabetically under each particular trade. In later sections names for the remainder of the United Kingdom are similarly classified. The final section, which appears for the first time in the current volume, gives lists of the manufacturers of iron and steel sections, indicating the sections and sizes rolled and the brands made; this section should greatly facilitate inquiries for iron and steel. Every care, we understand, has been used in compiling the volume, and the particulars given have been verified by a visit to each of the firms whose names appear in the directory. The volume contains over 2,000 pages and is strongly bound in red cloth covers; its price is 45*s.*

MODERN MARINE PROBLEMS IN WAR AND PEACE.*

By C. V. Drysdale, O.B.E., D.Sc.

The Council of the Institution having decided that the time has now come for the Kelvin Lecture to embrace other fields than those of Lord Kelvin's personal activities, have honoured me with an invitation to deal with the scientific investigations which have been carried out in marine problems during and after the war under the Admiralty at its various experimental stations. Apart from the interest and importance of the subject there is a fitness in coupling it with the name of Lord Kelvin, who did so much for the submarine telegraph and for navigation.

As everyone is aware the late war confronted this country with problems of the gravest character for which it was little prepared, and the submarine campaign soon showed the vital necessity for enlisting the highest scientific talent of the nation in attempting to solve them. The Institution co-operated enthusiastically in these efforts, both by the formation of its Anti-Submarine Committee, and by the great personal service of many of its members in actual experimental work in the Admiralty stations and elsewhere. For this reason it is specially fitting that such details of the scientific and experimental work as may be made public should be brought before the Institution.

Although the problems of submarine detection and of destructive or defensive measures have obviously been of chief importance, the work has naturally broadened its scope, and it has been found that the experience and devices obtained have the most valuable application to navigational problems which are now being energetically dealt with. The work may consequently be considered under four chief heads:—

I. Detection.
II. Defence and destruction.
III. Navigational applications.
IV. General scientific research.

Before entering upon details, however, some account should be given of the inception and development of the work.

Before the war, as is generally known, a large amount of valuable scientific work notably as regards radio-telegraphy and torpedo research and development was carried on for the Navy at Portsmouth under H.M.S. Vernon, and on the outbreak of the war this work was greatly extended, by the aid of a number of scientific men who joined the service, and by the opening of the Mining School at Portsmouth. The work of these establishments does not come within the lecturer's province to describe, and is naturally of a secret character, but it has been of the highest importance to the nation.

During the first year of the war the Government appointed the Board of Inventions and Research, a body of prominent scientists and technical experts whose task it was to deal with the flood of inventions and suggestions which poured in from all parts of the country. The President was Lord Fisher. The Board was sub-divided into various sub-committees, of which Section II, under the chairmanship of the Duke of Buccleuch, was concerned to a considerable extent, though not entirely, with the anti-submarine problem. It comprised Professors Bragg and Rutherford, Messrs. Duddell and Mers, and Sir R. T. Glazebrook; Sir Richard Paget and Lieut. the Hon. Walter J. James acting as secretaries. After inquiring into thousands of proposals the need was felt by this Section of some means of putting the more promising of these to some practical test. In November, 1915, two physicists were sent to the Hawkcraig Hydrophone Station (Captain—then Commander—Ryan) to work under the direction principally of Sir E. Rutherford.

In May, 1916, the staff was increased to five and Professor (now Sir W. H.) Bragg went to Hawkcraig as Resident Director of Research.

The need of further expansion being quickly felt it was decided to establish an independent station, and in January, 1917, Professor Bragg moved with his staff to Parkeston Quay, Harwich. The choice of locality was decided by the fact that Parkeston Quay was an important submarine base at which the scientific staff could come into intimate contact with submarines and their problems.

With the growth of the submarine menace there occurred a process of steady expansion. At the same time other stations primarily engaged in anti-submarine work were established under the Anti-Submarine Department of the Admiralty. In January, 1918, the Parkeston Quay Station was, for administrative reasons, also transferred to the Anti-Submarine Department, the Board of Inventions and Research reverting largely to its initial task of examining inventions. At the same time Professor Bragg went to the Anti-Submarine Department as Adviser to the Director of the Anti-Submarine Department, Colonel Eve succeeding him as Resident Director at Parkeston Quay.

In June, 1918, a deep-water sub-station was established at Dartmouth and an inland sub-station at the King George's Reservoir, Chingford. The station also lent a considerable number of its staff to various other stations, both service and experimental.

At the time of the Armistice the scientific staff numbered about 30.

The history of the Parkeston Quay Station has been dealt with, partly because it was the station with which the lecturer has been associated and partly because of its rather novel origin. It marks the commencement of a new official policy—that of inviting the co-operation of academic and technical experts. As has already been stated, however, quite a number of other special experimental stations sprang up.

The Hawkcraig Station, already mentioned, did the pioneer work in hydrophones, and in addition to training hydrophone operators, made important contributions to listening devices during the war under the directorship of Captain Ryan.

The Wemyss Bay Station originated as an offshoot from Parkeston Quay in the autumn of 1917, but became in January, 1918, an independent station under the Director of the Anti-Submarine Department.

The Portland Station originated in the work of Mr. Nash (of the Western Electric Company) on a towed hydrophone of his invention. Its chief work lay principally though not entirely in the development of this hydrophone and the training of operators.

The Lancashire Anti-Submarine Committee was a body of voluntary workers (including Mr. Redfern, Professor Marchant, Professor Miles Walker, Dr. Beatty, and Mr. H. C. Beaver) whose work consisted largely in experimenting on devices originated by its members.

The Shandon Experimental Station was established on the Gareloch in the middle of 1918 by the Clyde Anti-Submarine Committee, a body of Glasgow shipbuilders and other technical experts (Chairman, Mr. Gardiner). Mr. A. B. Field acted as Director. The facilities of the station were shared by the Lancashire Anti-Submarine Committee. Much excellent work was originated, but was too late to reach a service stage before the Armistice.

In addition to those who acted on the Board of Invention and Research or worked (in many cases voluntarily) at the various stations, a large number of men of scientific or technical eminence placed themselves at the disposal of the Board of the various committees.

During the latter part of the war there existed an efficient mobilisation of the scientific talent of the nation unique in the history of this country, and rapid advances were being made. Had this scientific force got into its stride in the early days, the history of the anti-submarine war at least might have been very different. Unfortunately, such mobilisation like the military mobilisation, required experience and much valuable time was lost.

Since the Armistice much of the research and fundamental experimental work has been concentrated at the Shandon Experimental Station, which was taken over by the staff of Parkeston Quay in March of last year. The situation of this station on the side of the Gareloch, which is an almost enclosed body of sea water about 5 miles long by one mile broad and averaging 100 ft. deep, is exceedingly favourable for preliminary experimental work and especially for research of a fundamental scientific character.

On the return of Colonel Eve to McGill University in April of last year the direction of the station was taken over by Major J. H. W. Gill, R.E., and since the commencement of the present year it has been in the hands of Captain Massey, R.N., as Senior Naval Officer, the research work being under the author as Scientific Director.

Physics of the Sea.—It is important at the outset to have a clear idea of the nature of the problems to be faced. What we are fundamentally concerned with is the generation, propagation, and reception of impulses or disturbances through the sea, which may be either mechanical or acoustic, electrical, magnetic, electromagnetic, thermal, optical, chemical, or possibly radiant in character.

The sea, as being a greatly extended medium of high density and elasticity, affords excellent propagation of mechanical or acoustic impulses, but its relatively high conductivity due to its salinity offers a formidable obstacle to the transmission of all electromagnetic disturbances, except those of the lowest frequency. At the ordinary supply of frequency of 50 periods per second about 94 per cent. of the amplitude is probably absorbed in 100 m. Optical, thermal and other forms of radiation are rapidly absorbed by it, and chemical action is obviously local and rapidly diffused, so that the problem of detecting the presence of a noiseless submerged body is of a most difficult character.

Unfortunately the difficulty is greatly enhanced by the existence of disturbances which may easily mask the impulses it is desired to detect. As we are mostly concerned with objects within a few hundred feet of the surface, the reflections which take place owing to the great difference in the mechanical and electrical properties of the sea and the air are frequently very serious, and give rise to embarrassing interference phenomena, which are further complicated by surface waves; and the same trouble is produced to a lesser extent by reflections from the bottom or from rocks in shallow water. Added to these disturbances are water noises caused by the waves and by the motion of an observing ship, or the noises caused by its machinery of propulsion, &c., as well as "earth currents" and magnetic storms.

In consequence of these disturbances, it is of little avail to attempt to overcome the limitations imposed by weakness of the source or by absorption in transmission, by increasing the sensitiveness of the observing device. Almost all our energies have to be devoted to the study and elimination of the disturbances, or to methods of discriminating between the source and the disturbances. In the latter respect acoustic methods have a great advantage, as the human ear is very sensitive to variations in quality as well as in intensity of tone, but unfortunately this power of discrimination often fails just where it is most needed, as the sounds sought for are frequently hardly to be distinguished from water noises.

Even assuming the problem of detection to be overcome, it is of little value unless the direction of the source can be obtained, and if possible its range. This introduces a new set of difficulties in which reflection, refraction and absorption play an important part. To take only one instance, the lines of magnetic force surrounding a submarine cable carrying an alternating current, which according to the ordinary textbooks should be in circles around the cable, are so distorted by the "skin effect" in the conducting water and by refraction at its surface that at a moderate range from the cable they are actually horizontal instead of vertical, showing the futility of relying on them for direction. This will be dealt with more fully later, but enough has been said to show that a new chapter in science has to be written on "The Physics of the Sea," and that we have to go to school again and imagine ourselves living in a conducting or semi-conducting lamina which is almost opaque to the majority of disturbances, acting on electro-magnetic waves as tar does to ripples, so that they are absorbed in a few wave-lengths.

We may now turn to a consideration of the technical problems and results, although it is to be regretted that many of the most interesting and effective devices cannot be described for obvious reasons.

I.—Detection.

It would take a large volume to describe the various schemes which have been proposed and experimented with for this subject. Perhaps the best way of introducing the subject is to consider all the physical and chemical disturbances which could possible be associated with a vessel—mechanical, acoustic, electrical, magnetic, &c., and the fundamental means of employing them. As regards the application of the disturbances, we may broadly distinguish between two methods:—

(A) Those in which the disturbance is emitted by the vessel to be detected;

(B) Those in which it is emitted by the observing station or a separate source, and is reflected or intercepted by the vessel to be detected.

We may distinguish these methods by the terms, direct or homo-dynamic, and reaction or hetero-dynamic, respectively. The distinction is the same as between a source of light like a star or lamp and a body which is seen by reflection or by the shadow it casts.

We may further subdivide the latter or hetero-dynamic method into three classes:—

(*a*) Simple reflection methods in which the object is detected in the presence of the primary impulse, *e.g.*, ordinary vision.

(*b*) Echo methods in which the primary impulse is interrupted during the reception of the reflected disturbance.

(*c*) Shadow methods in which the impulse is intercepted by the object to be detected.

This simple classification, although apparently somewhat academic, is of the utmost value in guiding research. The bulk of physical disturbances diminish in intensity according to the square or cube of the distance from the source, as well as by absorption, which may in many cases be very rapid. If the disturbance emanates from the vessel to be detected, it diminishes in this manner, but if it emanates from the observing station and is reflected from a small object such as a ship, both the emitted and reflected disturbances are similarly dissipated and absorbed, so that the effect received diminishes as the fourth to sixth power of the distance, and the absorption is squared. On this account hetero-dynamic methods, although they may deal with much larger initial disturbances, have very little chance of being effective in comparison with homodynamic methods, unless the emitted energy can be concentrated into a nearly parallel beam. Anyone who considers how little can be seen with the strongest arc lamp if it is not enclosed in a projector, will realise the importance of this point, but in the early days of detection experiments all sorts of suggestions for detection by inductance bridges, even with wireless frequencies, were put forward without the smallest chance of success. The figures given for the absorption of electromagnetic waves in Appendix III appear to show that for all frequencies above 100 $\sim$ per second the attenuation even at a range of 100 m. is so large as to render all detection almost hopeless, while at sonic or radio frequencies even direct transmission is very minute. Fortunately, in the majority of cases the sources are not very deep, so that the waves soon escape into the air and can be detected above the surface. For this reason signalling even at wireless frequencies is not impracticable, but any devices depending upon submarine reflection or reaction cannot be expected to give satisfactory results at high frequencies.

Electrostatic effects of course cannot be looked for in the case of a body immersed in a conducting medium, but magneto-static effects are not interfered with, as the permeability of the water is approximately unity.

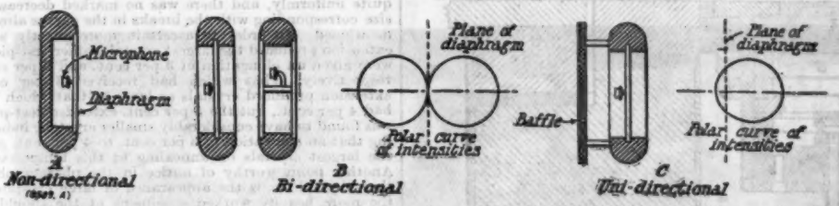
It need hardly be stated that optical methods if available would be by far the most valuable, as actual vision is the most conclusive evidence both of presence and of direction, but although sea water appears fairly transparent in thin layers, its absorption is too high to permit of objects being seen at any useful range, apart from the further difficulty of turbidity which exists in most shallow waters. In the clear water of the Mediterranean Sea the limit of visibility according to Professor Bragg is only about 200 ft., and it would not exceed probably 20 ft. in our home waters. The use of powerful illuminants also, even if of much value, is to be avoided as giving too much information. For these reasons scientific optical detection does not appear to have shown much prospect of utility, nor do thermal methods appear to have much applicability. A considerable amount of heat must obviously be emitted from a submarine, even when it is at rest, but radiation is of

* The eleventh Kelvin Lecture, delivered before the Institution of Electrical Engineers, April 15, 1920.

course rapidly absorbed. In very still water vertical convection currents would rise from the vessel and might easily be detected, but in moving water like the sea these must quickly be dissipated. Chemical action might possibly be detected at moderate ranges in still water, but, as with thermal effects, the moving water renders any possibility of direct chemical detection very remote.

It will be seen, therefore, that in spite of the number of phenomena theoretically available, and the possibility of applying them in various ways, the practical range of detecting devices is narrowed down to a comparatively few phenomena and modes of application, and it may be said that experience has very closely confirmed the conclusions which were drawn from the above considerations. More accurate knowledge of the transmission of impulses in the sea may enable us to design our detecting devices more efficiently, but the general lines on which such development should proceed seem fairly clear.

Fig. 1.—Types of hydrophones.



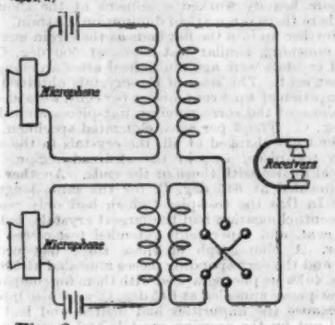


Fig. 2.—"Sum and difference" method.

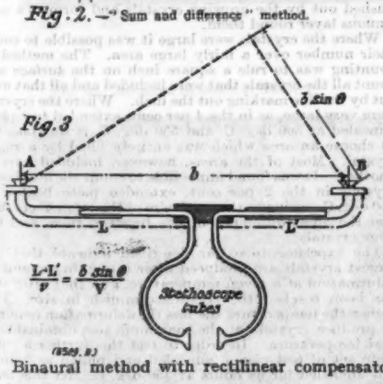


Fig. 3

Binaural method with rectilinear compensator.

Acoustic Devices.

The most simple device for acoustic detection is the elementary Broca tube consisting of a metal tube with a diaphragm at the bottom, which is dipped into the water. This device is practically equivalent to the familiar one of putting the ear to the ground or to a rod in contact with it. Improvements were made by the Americans in what were called C tubes, in which the diaphragms were replaced by rubber teats. Shortly after, microphones were introduced and various forms of hydrophones were devised.

Fig. 1 shows three forms of hydrophone which have proved of considerable service. In the first of these, marked A, a heavy circular metal case is provided with a diaphragm on one side, to the centre of which is attached an ordinary button granular microphone. This is a fairly sensitive and effective hydrophone and has been in continuous service.

As mentioned above, the determination of direction is as important as the actual detection, and Fig 1 (B) is one of the best forms of directional hydrophone. It consists of a thin metal diaphragm about 4 in. in diameter supported in a heavy lenticular-shaped ring so that the water is on both sides of it. At the centre of this diaphragm a simple granular microphone is fixed in a watertight capsule. When the sound waves strike the diaphragm nearly normally the hydrophone has its maximum sensitiveness, but when they are edge on, they act equally and oppositely on the two sides of the diaphragm, so that the effect is neutralised and no sound is heard. The positions of minima are very sharp and well defined.

The variation of intensity is approximately represented by the polar curve, which shows a minimum when either edge is towards the source. On this account this portable directional hydrophone is called bi-directional. Its sensitiveness is only about one-fourth of that of the non-directional form, but in spite of this it has proved of great value. A similar arrangement using two diaphragms coupled together had previously been employed by Mr. Sykes and Professor Morris, but its principle is the same.

By fitting one of these bi-directional hydrophones with what is termed a "baffle" plate, supported a few inches away from the face of the diaphragm as in Fig. 1 (C) the sound is virtually shielded from that face, and a single maximum can be observed when the other face is turned to the source. This gives us a uni-directional hydrophone, but its directional properties are inferior to those of the unbaffled bi-directional instrument as the maximum is not very sharp and the minimum is also blurred. For this reason the best results are obtained by coupling a uni-directional and a bi-directional hydrophone on the same vertical axis, and rotating them until silence is obtained on the latter combined with maximum intensity on the former instrument.

So far as fixed stations are concerned these hydrophones fulfil their promise very satisfactorily, but they are practically useless for the important case of listening from a moving ship, owing to the water noises produced by the motion. Very fair results have been obtained by enclosing the hydrophones in a water-filled stream-line case attached to the hull of the ship in which the hydrophones can be rotated. But even then the noise of the observing ship's machinery is a serious disturbance, so that listening can only be done when the engines are stopped, or at least running dead slow.

Towed Listening Devices.—As listening under way is of prime importance, an immense amount of work has been done on towed devices, in which microphones are enclosed in rigid or flexible stream-line bodies which are towed behind the ship. Considerable success has been obtained with some of these devices, but a difficulty then arises as regards direction. In some cases a small directional hydrophone can be employed inside the towed body, but it is frequently preferred to tow two or more hydrophones and to obtain directional indications either by "binaural" or "sum and difference" listening.

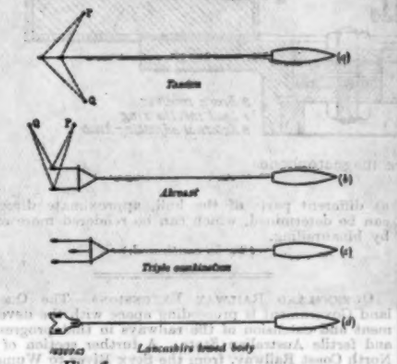


Fig. 4.—Towing schemes for hydrophones.

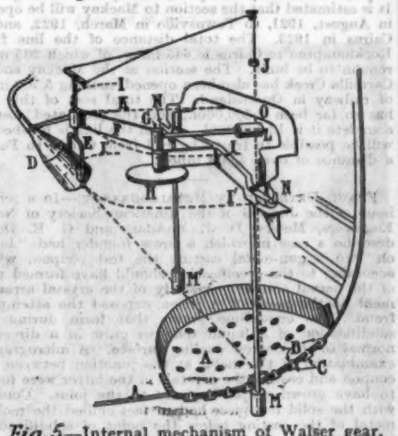


Fig. 5—Internal mechanism of Walser gear.

A Blister.
B, C Diaphragms.
D Collecting trumpet.
E—N Rotating gear.

The binaural method developed largely in the United States depends upon the simple principle that if sound falls upon two receivers separated by a short distance, it reaches them at different times unless the source is in the median plane between them. If the two receivers communicate with the two ears, the source will appear to be on one side or other; but by rotating the bar carrying the receivers, the source appears to cross over behind the observer from one ear to the other, and this cross-over occurs when the bar is perpendicular to the direction of the source. This method has been found of the greatest value in the location of aeroplanes by employing two trumpets communicating by stethoscope tubes to the observer's ears, but it has been much less easy to apply to hydrophones, owing firstly to the difficulty of producing granular microphones which are identical in acoustic properties, and secondly to the fact that it is often impossible to rotate the coupled hydrophones when attached to a ship or enclosed in towed bodies. The difficulty is enhanced also by the fact that the velocity of propagation, and hence the wave-length of a given sound, are nearly five times as great in water as in air, so that the distance between the hydrophones must be correspondingly increased.

If two ordinary microphones are fixed close together so as to be similarly affected by a source of sound, and are joined to the primaries of two ordinary telephone induction coils, as in Fig. 2, then if the secondaries of these coils are connected in series to a pair of receivers, the effect observed is either the sum or the difference of the effects of the two microphones according as the secondaries are assisting one another or are in opposition. If the two microphones behave exactly similarly, a loud sound should be heard when they are assisting; and no sound at all should be observed when they are opposing; but with ordinary carbon microphones it frequently happens that hardly any difference is noticeable, owing to different phase relations in the two microphones. By replacing the ordinary mica diaphragms by indiarubber the selective properties of the microphones are much reduced and better balance can be obtained. In this way and by enclosing the microphones in rubber blocks, fairly perfect pairing can be obtained, which is essential if correct binaural listening is required.

As above mentioned, however, the rotation of the bar carrying the microphone is a troublesome matter, and to obviate this, various forms of binaural compensator have been employed which enable directions to be obtained without rotation of the microphones. These compensators depend on the principle of introducing variable lengths of air path between the receivers and the observer's ears. If the sound reaches both microphones in the same phase, i.e., from a point in the median plane between them, and each microphone is connected to a receiver at the corresponding ear of the observer there will be binaural balance; but if the source is on one or other side of this plane there will be a difference of time between the arrival of sound at the two microphones, which can be compensated by a different length of air path between the receivers and the ears. Fig. 3 shows diagrammatically a simple form of straight sliding compensator, in which the receivers are fixed at opposite ends of a long straight tube, the centre portion of which can slide in the end portions so as to obtain the required difference of path. A more convenient form of compensator is made by the Automatic Telephone Company, and is similar in principle to the original American instrument. Two circular plates are arranged to revolve smoothly over one another, and have grooves cut in their faces, forming the air paths. The sound from the receivers is introduced into these grooves and taken from them to the ear by rubber tubes, and by revolving one of the discs the length of air path on one side is lengthened, and on the other side shortened, so that by turning the compensator the same effect is produced as by rotating the microphones.

Instead of binauralling, some observers prefer to work directly on the "sum and difference" principle above described. If the source is in the median plane between the microphones, and they are properly paired, there will be no sound with the "difference" connection; but if it is to one or other side of this plane, there will be a certain amount of sound which can be balanced out either by swinging the microphone or by introducing the compensator as above. Professor Spearman has introduced a reversing stopcock device for interchanging the stethoscope listening-tubes to the ears, which increases the accuracy of binaural listening.

Lastly, dealing with directional combinations, two or more simple hydrophones are towed simultaneously so as to have fixed base lines, and the binaural or the "sum and difference" principle is employed with them. Two such hydrophones can be towed one behind the other as in Fig 4 (*a*), but in that case there will be no indication on which side the source is; the time difference is evidently the same for any point on a circle surrounding the axis, or for the points P and Q in the figure. By towing two hydrophones abreast with a spreader as in (*b*) this ambiguity disappears, but it is then uncertain as to whether the source is ahead or astern. If three hydrophones are used as in (*c*) this ambiguity is eliminated, as binauralling can be conducted on any pair. In Fig 4 (*d*) we have the towed body devised by Messrs. Redfern and Doble of the

Lancashire Group in which three hydrophones are mounted on a board with streamed edges.

The above is only an outline of the immense amount of work which had been done on towed listening devices, to say nothing of the special cables which have been constructed to take the considerable strains involved. For this purpose cab-tyred cables with central steel cores have been largely used, and the various cable manufacturers have rendered great service in their design and construction.

Inboard Listening.—Although the towed devices have met with a certain measure of success, they are troublesome to handle, and the modern tendency is in favour of the development of listening apparatus for use on board ship. Although this is a difficult problem, on account of water and ship noises, there is a valuable principle which greatly assists its solution. This may be called the principle of acoustic integration, apparently first put forward by Professor A. W. Porter, which points to the employment of large flat surfaces for reception.

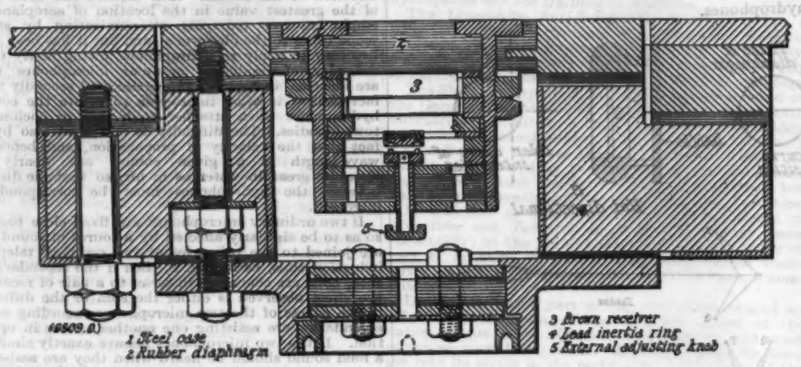


Fig. 6.—Air-drive magnetophone.

Many important applications of this principle have been made both in the United States and in this country, and considerable success has been obtained with the devices based on it. The chief objection to it is that it is obviously impracticable to swing a large receiver on board ship to receive from various directions; but this difficulty has been to a large extent overcome by introducing a variable phase difference into the microphone or other receivers attached to different parts of the diaphragm, thus enabling a maximum sensitiveness to be obtained for various directions of the source. Professors Mason and Pierce have produced valuable inboard listening devices in this way, and the author has devised a "magnaphone" or large magnetophone which applies the principle in the simplest possible manner.

Before leaving this subject two interesting devices employing an analogous principle may be described. The first of these is the Walser gear invented by Lieutenant Walser of the French Navy. Instead of using a large plane receiving-surface he employs a pair of "blisters" or spherical dilatations on the two sides of the hull. Each of these blisters is about 3 ft. 6 in. diameter and is provided with a large number of thin circular diaphragms, so that the arrangement looks like the compound eye of an insect. When sound waves fall on this blister the vibrations of the diaphragms are communicated to the interior air and come to an approximate focus as in the case of a lens or rather of a "zone plate." A conical trumpet placed at this focus and provided with a rubber tube and ear piece is all that is required for listening. As the direction of the source changes, the position of the focus revolves round the centre of curvature of the blister, and by mounting the trumpets on suitable rotating gear, the observer is able to locate the source by first observing whether the sound is louder on the port or starboard side and then rotating the trumpets till a maximum is obtained. Fig. 5 shows the internal mechanism of a Walser cabin.

A second device of great theoretical interest is the hydrogen or H tube of Mr. H. W. Hilliar. The velocity of sound in hydrogen and in water is very nearly equal. If, therefore, sound arrives at the end of a long tube at practically the same speed as it does in the water outside, and if the tube is turned towards the source, the sound entering at every part of it reaches a receiver or listening tube at the end in the same phase. This may be called the principle of longitudinal integration, as distinguished from that of transverse integration previously described, and it has the advantage that the whole of the sound collected from the entire surface of the tube is concentrated on a single receiver. If the source is not in line with the axis of the tube the axial velocities are not the same, and partial cancellation results, so that the device is directional. At ordinary temperatures, the velocity of sound in hydrogen is somewhat less than that in water, but by steam heating the hydrogen the velocities can be made practically exactly equal, and the device is found to have fairly definite directional properties.

There can be little doubt that there is a great future for inboard listening devices, especially if improvements are made in reducing engine noises in the ship, but the great size of the integrating devices renders experimental development slow. In the meantime good work has been done in the application of inboard magnetophones with devices for eliminating water and other noises on the interference principle. Magnetophones are inferior to microphones in actual sensitiveness, but they have the advantage over them of having no grating or crepitational noises, so that they will stand considerable amplification, and they are easy to pair for binauralling.

Fig. 6 shows Mr. B. S. Smith's form of "air drive" magnetophone, which consists simply of an ordinary Brown reed telephone-receiver mounted behind a diaphragm fixed on a heavy metal ring which is attached to the ship's side with the intervention of a rubber sound-insulating ring. The vibrations of the diaphragm are communicated to the reed through the air in the interior, causing it to vibrate and to act as a magnetophone. By employing four or more of these devices at different parts of the hull, approximate direction can be determined, which can be rendered more exact by binauralling.

(To be continued.)

Queensland Railway Extensions.—The Queensland Government is proceeding apace with the development and extension of the railways in that progressive and fertile Australian State. A further section of the North Coast Railway, from the Styx River to Wumalgi, 94½ miles from Rockhampton, was opened on August 5. It is estimated that the section to Mackay will be opened in August, 1921, to Townsville in March, 1922, and to Cairns in 1923. The total distance of the line from Rockhampton to Cairns is 645 miles, of which 205 miles remain to be built. The section at the Mackay end to Carmilla Creek has also been opened, making 5,700 miles of railway in Queensland. The total cost of this line has so far been 2,500,000*l.*, and the estimated cost to complete it is 13,000,000*l.* When the line is finished, it will be possible to travel by rail from Cairns to Perth, a distance of over 4,000 miles.

Fraud Detected by Metallography.—In a recent issue of the Journal of the American Society of Naval Engineers, Messrs. D. J. McAdam and G. E. Doan, describe a case in which a brass founder had "burnt on" to a gun-metal casting the test coupon, which according to the specification should have formed part of the actual casting. A study of the crystal arrangement at the point of junction exposed the attempted fraud. The crystalline grains that form during the solidification of a liquid tend to grow in a direction normal to the nearest cooling surface. A micrographic examination of the metal at the junction between the coupon and casting the crystals in the latter were found to have grown perpendicularly to the joint. Contact with the solid test-piece had in fact chilled the molten metal of the casting below the point of solidification, whilst the test-piece itself had not been melted even superficially.

Pressure Drop in Radiator Air Tubes.—Report No. 88, recently received from the National Advisory Committee for Aeronautics, Washington, D.C., U.S.A., describes an investigation of the effects of pressure drop in the air tubes of radiators. The investigation was carried out for the committee at the Bureau of Standards, and the pressure measurements were made by means of a small steel tube 0·04 in. in diameter and 20 in. long, with a static pressure opening near the central part, passed through an air tube of a radiator. The main conclusions drawn from the experiments are that the drop in static pressure, and the pressure gradient in the air tubes, are practically proportional to the square of the air flow for a given air density, and that the skin friction is approximately the same as for long pipes; these facts appear to indicate that the flow is turbulent. Frictional resistance was found to be two-thirds of the head resistance for a radiator having circular cells $\frac{1}{16}$ in. in diameter and 5 in. long, and one-half the head resistance for a radiator with cells $\frac{1}{8}$ in. square and 4·8 in. long. It was also found that supplying heads to a radiator with circular cells $\frac{1}{4}$ in. in diameter and 4 in. long increased the pressure gradient in the tubes by about 15 per cent. for a mean temperature difference of 110 deg. F., between the water and the entering air. A copy of the report may be obtained upon request from the committee, at the address given above.

CRYSTAL GROWTH AND RECRYSTALLISATION IN METALS.*

By Professor H. C. H. Carpenter, M.A., Ph.D., A.R.S.M., F.R.S., Past-President (London), and Miss C. F. Elam, Member (London).

(*Concluded from page* 426.)

A series of the stressed test-pieces was annealed for 65 hours at 550 deg. C. A photograph (Fig. 39) of them after etching shows the relative crystal size obtained after each successive increase of deformation. The largest crystals were found after 4 per cent. extension. After 2 per cent. the test-piece consisted partly of large crystals and partly of small unaltered crystals of the same size as those of the original annealed sheet. With increase in deformation the crystals diminished in size quite uniformly, and there was no marked decrease in size corresponding with the breaks in the curves already mentioned. In order to ascertain more exactly what extension produced the largest crystals, other test-pieces were given an elongation of 3 per cent. and 5 per cent. respectively. That which had received 3 per cent. extension produced crystals as large as that which had had 4 per cent., but the 5 per cent. extended test-piece was found to have considerably smaller crystals, indicating that an elongation of 3 per cent. to 4 per cent. gave the largest crystals on annealing at this temperature. Another point worthy of notice in the photograph of these test-pieces is the appearance of large crystals in the more heavily worked specimens at the shoulders, *i.e.*, where there is a marked diminution of strain. They grow further up into the flat ends as the strain increases.

On annealing similar test-pieces at 500 deg. C. the largest crystals were again obtained after an elongation of 4 per cent. The sizes of the crystals obtained after an elongation of 4 per cent. and 6 per cent. were identical with those of the corresponding test-pieces annealed at 550 deg. C. The 2 per cent. elongated specimen, however, had not changed at all, the crystals in the centre of the test-piece, *i.e.*, in the strained region, being identical in size with those of the ends. Another series was annealed at 645 deg. C. for the same length of time. In this the test-piece which had only received 2 per cent. elongation had the largest crystals, both the 4 per cent. and 6 per cent. extended test-pieces being smaller. A photograph of these three test-pieces is given, and the corresponding pieces annealed at 500 deg. C. (Fig. 40) were photographed with them for comparison. The test-pieces annealed at 645 deg. C. were also interesting, because the impurities had melted and had been pushed out by the growing crystals and formed a continuous layer round them.

Where the crystals were large it was possible to count their number over a fairly large area. The method of counting was to rule a square inch on the surface and count all the crystals that were included and all that were cut by the line marking out the inch. Where the crystals were very large, as in the 4 per cent. extended test-piece annealed at 500 deg. C. and 550 deg. C. it was possible to choose an area which was entirely filled by a single crystal. Most of the areas, however, included part of another. It was found impossible to count the number of crystals in the 2 per cent. extended piece heated at 550 deg. C., owing to the small size of the original crystals and the great difference in size between them and the large crystals.

The experiments so far described indicate that the largest crystals are produced after a certain amount of deformation at a given temperature, and that after this has been reached the crystals diminish in size. The higher the temperature the less the deformation required to produce crystals of the maximum size obtainable at that temperature. In order to test this further a complete set of test-pieces, annealed and pulled as before, was annealed for 65 hours at 350 deg. C. At this temperature complete mechanical softening is effected in 24 hours, and most of the hardness is lost in the first hour. There was no sign of crystal growth in any of the test-pieces up to 8 per cent. elongation. That which had been stretched 10 per cent. grew, however, and formed large crystals, approximately equal in size to the 8 per cent. test-piece annealed at 550 deg. C. From 10 per cent. onwards the crystals decreased in size quite uniformly, as at 550 deg. C. But the crystals produced were larger than those of the corresponding test-pieces annealed at 550 deg. C. If the crystals were counted as described previously, it was found that for 10 per cent. elongation at 550 deg. C. there were 760 crystals, and at 350 deg. C. there were 144.

These test-pieces all showed larger crystals at the shoulders, but they were small compared with similar crystals formed at the higher temperatures. The most remarkable feature of this series is that there was apparently no change on annealing the test-pieces, which had been stretched less than 10 per cent. A similar instance is that of the 2 per cent. elongated test-piece annealed at 500 deg. C. This also showed no tendency to develop large crystals. On annealing all the test-pieces that had already been annealed at 350 deg. C. for 65 hours, for 18 hours at 550 deg. C., the test-pieces that had been pulled 2 per cent., 4 per cent., 6 per cent. and 8 per cent. developed large crystals, exactly as if they had never been annealed previously at 350 deg. C. but had been annealed directly at 550 deg. C. In fact, it was impossible to distinguish them in any way from those shown in Fig. 39. From 10 per cent. onwards there appeared to be only a slight increase of size in the crystals of those which had been more heavily stressed and in addition large crystals growing up into the flat

* Abstract of a paper read before the Institute of Metals, at Barrow-in-Furness, on September 15.

ends were formed also similar to those produced at the higher temperature.

It is possible, therefore, to anneal these test-pieces for 65 hours at 350 deg. C. without destroying the effect of work which produces crystal growth on annealing, although mechanical softening is then complete.

This series also shows very clearly how abruptly the largest crystals make their appearance. There is no gradual increase in size up to the largest corresponding to the gradual decrease in size as soon as the maximum is passed. All the evidence points to one conclusion, viz., that the large crystals grow directly from some of the original crystals without a previous recrystallisation. Further confirmation of this statement was obtained by annealing test-pieces which had received an elongation of 4 per cent. for short periods at 500 deg C. The large crystals began to appear first at the four shoulders after about 30 minutes' annealing. The unchanged part of the test-piece consisted of crystals of exactly the same size as the original ones; in fact, the straining followed by heating had had no visible effect upon them. The maximum effect was produced in about one hour at 500 deg. C., while at 550 deg. C. 30 minutes was always sufficient. This could be tested easily in samples where the crystals were large. After etching for the first time the crystals were outlined by a fine pencil mark, and the specimen annealed for a further period and re-etched. There was no change. Specimens treated in a similar manner were also heated at a higher temperature when no further growth took place, indicating that the stimulus to growth had all been exhausted in the formation of the crystals on the first annealing.

Similarly, the large radiating crystals formed at the shoulders of the test-pieces showed no tendency to grow into the unstrained part. According to Jeffries, Chappell, Rosenhain, &c., because of their greater size and consequent greater surface energy they should eventually be able to absorb all neighbouring crystals smaller than themselves. The higher the temperature and the greater the deformation, the greater the area they occupied. In fact, in some cases they extended to the end of the test-piece or met other large crystals growing down from the marks made by gripping the test-piece in the machine. It must be remembered, however, that this area had been subjected to strain. Even at 645 deg. C. the large crystals did not extend over the whole of the ends. A small strip on either side of the broadest part, which apparently had not been strained, consisted of small crystals. This can be seen in the photographs of these test-pieces (Figs. 39 and 40).

FIG. 39. Annealed for 65 hours at 630° C., after pulling.

Elongation 2% 4% 6% 8% 10% 12% 14% 21% 31%

Reduced to one-third natural size.

FIG. 40. Annealed 65 hours at 650° C. Annealed 65 hours at 500° C.

Elongation 2% 4% 6% 2% 4% 6%

Reduced to one-third natural size.

The abnormally large crystals formed on annealing after a small deformation, and the gradual decrease in their size as the deformation increases, are considered by the authors to be due to the following causes.

As already mentioned, the first effect of small amounts of deformation is to produce slip-bands (and in some metals twins). Provided the stress does not exceed a certain value, this is all that happens. A very little more deformation, however, causes a change in a few of the crystals, so that on heating they grow. The less the strain the fewer the centres from which growth will start and hence the larger the crystals ultimately formed. The largest crystals began to appear after 2 per cent. elongation at 550 deg. C., but their capacity for growth was exhausted when only about one-half the total number of crystals had been absorbed. At 645 deg., however, they were able to effect complete absorption owing to the greater mobility conferred by the higher temperature. But the higher temperature enabled growth to start from more centres, so that the final crystal size was smaller than at 550 deg. C. Similarly, as the deformation increases, more crystals will be strained to the critical amount to produce growth on heating, and there will accordingly be a corresponding decrease in crystal size.

Now, it has been shown in the above experiments that the least possible deformation necessary to produce growth on heating gives rise to the largest crystals. This is most clearly brought out in the experiment at 500 deg. C., where 2 per cent. elongation produces no growth and 4 per cent. gives rise to the largest crystals. In the latter case about ten crystals out of many thousands present were strained to the critical amount, which enabled them to absorb all their neighbours on heating. It is, of course, possible to imagine a case in which only one of these crystals was strained to the critical amount, which would have to have been rather less. In this case it would be expected that the whole of the strained area would ultimately have consisted of one crystal instead of ten, provided that suitable conditions were maintained. Precisely what these conditions should be cannot as yet be predicated. One condition, however, is essential, viz., that all the remaining crystals must also be in a strained condition. It has already been pointed out that there is always a strip of small unaltered crystals on either side of the flat ends of the test-pieces, even when they had been annealed at 645 deg. C., and that the large crystals showed no tendency to grow into them. Owing to their position, they had not been strained by the pulling of the test-piece. It seems clear, therefore, that the crystals must all be strained to some extent if they are ultimately to be absorbed by one, and it is probable that the degree of strain would have to be uniform, or at any rate only vary within a very narrow margin. A high temperature, if not absolutely necessary, is certainly a favouring condition, since it confers increased freedom of movement on the crystals, but the actual temperature at which growth progresses most favourably depends on the degree of deformation. The conditions for the production of a single crystal are, therefore, that every crystal in the complex shall be strained a certain small amount, and that one of them shall be strained rather more than all the rest. How unlikely it is that such a condition would ever be realised in practice it is unnecessary to emphasise, but theoretically such a case can quite well be conceived.

The structural changes produced in a crystal aggregate by deformation followed by heat may be summarised somewhat in the following way:—The first effects are slight. They are revealed by slip-bands, and in some cases twins. The former are completely, and the latter to some extent, removed by heating. No change is observed in the shape of the crystals. The boundaries appear unaffected, and apart from the twins there is no change in orientation. Thus far only the interior of the crystals is affected. No identities are lost. Somewhat greater deformation, however, produces crystal growth, and at this stage the boundaries of the crystals become active. The activity is shown in the capacity of the growing crystal to push forward its boundary in certain directions by which other crystals are invaded. But even at this stage the orientation of the growing crystals is maintained. That of the crystals grown into is, of course, destroyed unless it happens to be the same. The third stage produced by still greater deformation appears to take place exclusively in the boundaries of the deformed crystals. It is here that the new crystals are born, indicating the destruction of the original crystals and a complete change of orientation. Whereas, therefore, the early effects of deformation are shown in the interior of the crystals, the later ones appear to take place entirely at the boundaries.

The chief facts established by these experiments are:—

CRYSTAL GROWTH AND RECRYSTALLISATION IN METALS.

Magnification 16 diams. Oblique illumination.

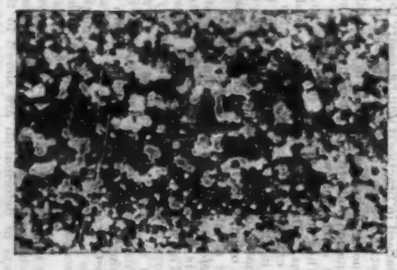


Fig. 41. 1 hour at 550° C.

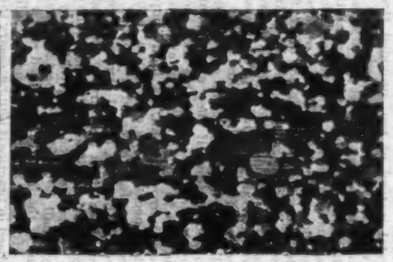


Fig. 42. 3 days at 550° C.

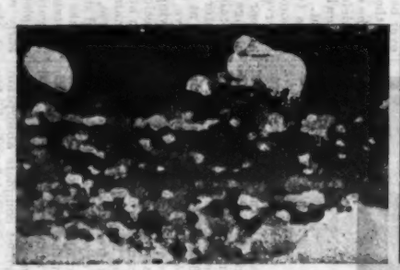


Fig. 43. 1 week at 550° C.

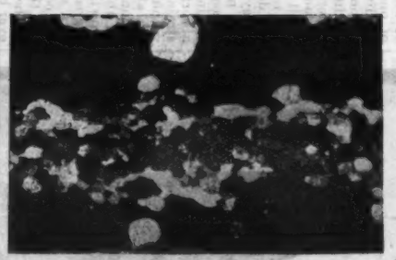


Fig. 44. 1 week at 550° C.

Fig. 45. 2 weeks at 550° C.

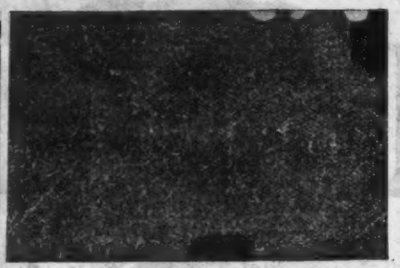


Fig. 46. 2 months at 550° C.

Reduced by one-sixth.

(1) The largest crystals are always formed after the minimum amount of stress sufficient to produce growth, which minimum is determined by the annealing temperature; (2) the lower the annealing temperature, the greater the stress required to produce these large crystals; (3) there is no gradual increase in size from the original sized crystals up to the largest. The largest form directly from them; (4) the large crystals formed at the shoulders of the more severely strained specimens grow further into the flat ends the higher the temperature and the greater the strain. They do not grow into the unstrained regions; (5) test-pieces pulled and annealed at a low temperature, which show no change at that temperature, will produce large crystals if annealed at a higher temperature equal in size to those produced normally at that temperature for the same degree of elongation.

Reference has already been made to a hypothesis that the final and stable condition of a crystal aggregate is only reached when all the crystals have united to form a single crystal. In order to test this some very prolonged annealings of aluminium sheet were carried out at a high temperature.

The first experiments were made with 99·6 per cent. pure aluminium sheet, and were employed in an investigation of the recrystallisation of this material. The longest period of annealing was one year at 250 deg. C. and 300 deg. C. At both these temperatures recrystallisation was followed by crystal growth, and the maximum size was reached in six months at 250 deg. C. and in ten weeks at 300 deg. C. Although both these were annealed in all for one year, yet there was no visible change in crystal size after the times mentioned.

The most interesting results were obtained on annealing at 550 deg. C. Recrystallisation is complete in one hour at this temperature (Fig. 41). The crystals increase slightly in size up to three or four days (Fig. 42). After this a few large crystals begin to appear on the surfaces of the sheet. They are so far apart that many sections might be taken before including one of them. In a week, however, the sheet is largely composed of them, with small unchanged crystals between (Figs. 43 and 44).

Fig. 47. 3 days at 550° C.

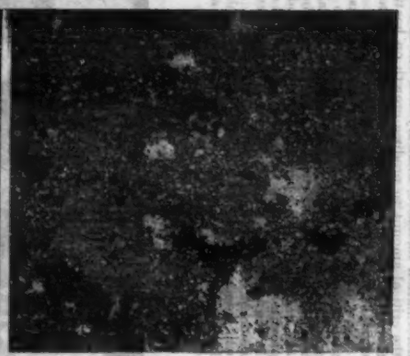


Fig. 48. 1 week at 550° C.

Fig. 49. 2 weeks at 550° C.

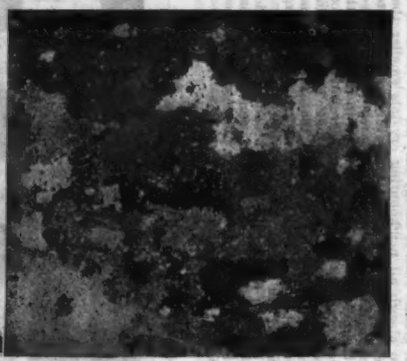


Fig. 50. 1 week at 550° C.

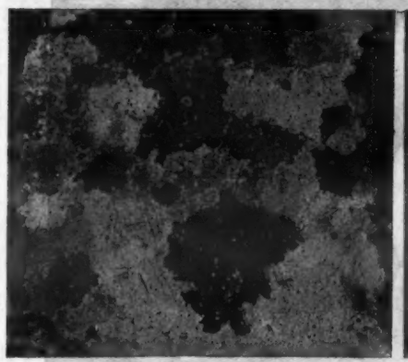


Fig. 51. 2 weeks at 550° C.

Fig. 52. 1 week at 645° C.

Magnification 1½ diams. Reduced by one-sixth.

Fig. 45 shows a typical area at the end of a fortnight. The sheet consists chiefly of two large crystals with a few smaller crystals unabsorbed between them. Some of the small isolated crystals seem to persist indefinitely,

and are still to be found in metal annealed for four months. The last photograph of the series (Fig. 46) shows how the sheet can consist almost entirely of a single crystal in section. All the photographs referred to above show a complete section through the sheet, and it will be noticed that after one hour's annealing the crystals on the surfaces of the sheet are the smallest, although the large crystals begin to form there. Some of those crystals are several inches in area and are always longer in the direction of rolling. The next photographs, slightly larger than natural size (Figs. 47, 48 and 49) illustrating the formation of these large crystals on the surface of a sheet, show more clearly the manner in which they first make their appearance. These photographs are taken from another sheet, rather less pure than the first, and the ultimate crystal size attained was considerably less than in the purer sheet. Figs. 50 and 51, however, are of a purer sheet, and show the crystal size after one week's and two weeks' annealing. Those should be compared with Figs. 48 and 49. There is considerable evidence that the presence of impurities very much impedes the growth of large crystals. Ordinary commercial sheet seldom shows this characteristic, and if any large crystals appear at all they are few in number and are confined to the surface.

Annealing this sheet at 500 deg. C. for long periods failed to produce this extraordinary growth. Recrystallisation proceeded as at 550 deg. C., but beyond a slight general increase in crystal size there was no further change. It is probable, however, that the degree of work determines the temperature at which this growth will take place, as a hard-drawn aluminium bar produced large crystals at 500 deg. C. equally well as at 550 deg. C.

It was thought that if the temperature of annealing were raised, still larger crystals would be formed. The contrary proved to be the case, the crystals being actually smaller. They were, however, more uniform in size, and the actual number present after annealing at 550 deg. C. and 645 deg. C. respectively probably did not differ so much as might be expected at first sight. A photograph (Fig. 52) of a piece of sheet annealed for one week at 645 deg. C. should be compared with Fig. 50, which represents the same sheet annealed for one week at 550 deg. C. A still more remarkable contrast is shown in Fig. 53, which is a photograph of two test-pieces of the purest aluminium sheet annealed at 550 deg. C. and 645 deg. C. respectively until no further change appeared to take place. This photograph also gives some idea of the size of the crystals formed on the pure sheet.

The foregoing experiments were carried out with small specimens. Later, however, in order to avoid any effects that might be due to distortion of the edges by cutting, large pieces of the sheet, 9 in. by 4 in., were annealed and the whole piece etched before sections were cut from it for microscopic examination. In no case could any differences be observed near to the cut edges, but in view of the effects of small local deformation it was considered a necessary precaution to take. It must be remembered, however, that the pieces were cut from the sheet while still in the hard-rolled condition, when apparently local stresses have not the same influence as if the metal had been annealed previously.

Fig. 53. Test pieces of pure aluminium annealed at 550° C. and 645° C. respectively.

Reduced to one-third natural size.

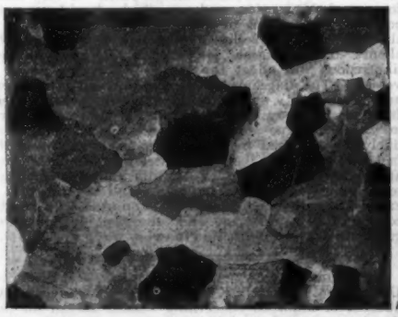


Fig. 54. ×10.

Fig. 55. ×10.

Antimony-tin alloy heated until no further growth took place. Oblique illumination.

Reduced by one-sixth.

Experiments with hard-drawn aluminium bar, ½ in. diam., and sheets of different thicknesses gave somewhat different results. In both large crystals were formed, but in neither did they penetrate to the centre. In the bar there was always a core of small crystals, which failed to disappear after annealing for two months at 550 deg. C. In the thicker sheet the large crystals were confined exclusively to the surface layers.

In all the experiments described above, crystal growth apparently ceased in from two or three weeks according to the sheet used. The longest annealing period at 550 deg. C. was four months, and as no increase in crystal size took place after three weeks in most of the samples examined, it was considered probable that equilibrium had been reached. Reference to the photographs show the very different size of the crystals found in the same sheet, and also the variety of crystals found in different sheets. It is probable that the latter result is due chiefly to slightly varying amounts of impurities in the sheets used. With regard to the former, if equilibrium had been reached—and the evidence is distinctly in favour of such an assumption—it follows that there is good reason for questioning the hypothesis that the final state of equilibrium of a crystal aggregate is a single crystal, except under the conditions particularised above. The evidence obtained in this research points also to the conclusion that a large crystal will not necessarily absorb a small one with which it happens to be in contact. This point is further illustrated by two photographs of the antimony-tin alloy, which showed no further growth on heating. Even the smallest change is noticeable in this alloy, and no such change was visible in these specimens although annealed for one month at 200 deg. C. after equilibrium had apparently been reached. In one of these (Fig. 54) the crystals are fairly uniform in size. In the other (Fig. 55) the largest crystal in the centre of the field is many times greater than some of its neighbours. Yet both these specimens showed no signs of further growth.

These experiments are interesting because: (1) The large crystals of aluminium were not formed rapidly on heating the cold-worked material, but only after annealing for three days at a high temperature (550 deg. C.); (2) they were not formed at all at 500 deg. C., and were not so large at 645 deg. C. as at 550 deg. C.; (3) The four different sheets tested gave different final results, due largely to the slightly varying amounts of impurity. The purest sheet gave the largest crystals, while ordinary commercial sheet frequently gave none; (4) the limit of growth was reached in a certain fixed time, beyond which no further change could be detected; (5) The large crystals formed appeared to be in equilibrium with the small ones when the fina condition was reached.

It is considered that the evidence relating to crystal growth and recrystallisation which has been brought forward in this paper is sufficient to warrant the following conclusions: (1) Neither crystal growth nor recrystallisation will take place unless the metal has been subjected to plastic deformation (in the absence of a change of phase). (2) Neither crystal growth nor recrystallisation will take place after plastic deformation unless the metal is heated to certain minimum temperature and for a certain minimum time. (3) The effects of work may be divided into three categories, according to the amount of deformation, (a) the production of twins or slip-bands, or both, followed neither by growth nor recrystallisation on heating; (b) the production of twins or slip-bands, or both, followed by crystal growth on heating; (c) the production of twins or slip-bands, or both, followed by recrystallisation and growth on heating. (4) The degree of deformation which will produce any of the effects enumerated above depends upon the temperature of heating. The higher the temperature, the less the deformation required. (5) The effects produced by deformation are limited in extent and depend on the amount of deformation, the annealing temperature, and the period of heating. No evidence has been obtained in favour of the hypothesis that before equilibrium is reached growth should continue until the whole piece of metal consists of one single crystal. On the contrary, all the evidence obtained by the authors is against it, except under one particular set of conditions. (6) Recrystallisation begins in the crystal boundaries of the old distorted crystals. It starts from a few points and gradually spreads throughout the mass. (7) Recrystallisation is always followed by growth of the re-oriented crystals into each other. (8) Crystals can both grow and be grown into at one and the same time. (9) A large crystal may grow at the expense of a small one, or a small crystal may grow at the expense of a large one. (10) Neither similarity nor diversity of orientation affects the growth of one crystal into another. (11) The size of the crystals in a piece of metal that has reached equilibrium may vary within very wide limits. A large crystal does not necessarily invade a small crystal with which it is in contact. (12) In the authors' experiments growth always took place by "boundary migration" and not by coalescence.

It is necessary to review briefly the theories of crystal growth which have been already put forward in the light of the evidence obtained in this research. These can be divided into two groups: (1) Those which take into consideration the part played by plastic deformation in promoting crystal growth; (2) Those which do not.

1. To the first group belongs the theory of Ewing and Rosenhain. This theory, which has already been described briefly, was put forward nineteen years ago. It depends entirely on the assumption that there is always sufficient impurity even in the purest metals to form a eutectic intercrystalline layer, and that in the cast state this layer completely separates the crystals. The effect of work is to break the layer in a few places and allow direct contact between the crystals. An electrolytic action is then set up and growth occurs by diffusion through the eutectic. Present-day evidence, however, is strongly against the view that in the purest metals there is sufficient impurity completely to surround the crystals. Moreover, this theory does not explain why growth occurs in a worked and annealed metal when the impurities are no longer in the crystal boundaries, but are distributed throughout the crystals themselves or have gone into solution. Furthermore, in a paper on the "Intercrystalline Cohesion of Metals," Rosenhain and Ewen denied that the intracrystalline fracture obtained when metals were broken near their melting points was due to small amounts of impurities in the crystal boundaries, because they did not admit the presence of such impurities in the metals they used. One of these was pure gold. Rose, however, has found that even the purest gold will recrystallise and the crystals grow on heating. For these reasons it is considered that this theory fails to provide an acceptable explanation of crystal growth.

Chappell put forward two alternative suggestions as to why the crystals of worked metals grow. He realised that account must be taken of the view that those of castings do not grow. (As explained, this view had not then been rigorously tested.) His first supposition was that if identity of orientation were necessary before crystal growth could take place, then the energy given to the crystals by work enabled them to rotate on their axes parallel to each other and so unite. The evidence produced in the present research is, however, all against the view that similarity of orientation is necessary before growth will take place. Secondly, he supposed that two crystals unite in the same way as two pieces of iron weld together. Work was necessary to break up any separating layer and establish molecular contact, and the crystals united directly and not by a process of gradual transference. This again is contrary to what has been observed throughout this research. Growth always took place by gradual migration of one crystal into another.

2. To the second group of theories belong those of Rosenhain and Jeffries, based on the "amorphous cement" theory of the first named, according to which a layer of amorphous material, similar to what Beilby suggested was formed in the working of metals, exists as a layer between the crystals of all metals in whatever condition they are, and holds them together. The molecules of this layer are supposed, under the influence of heat, to attach themselves to one of the adjacent crystals and a new amorphous layer is formed. Neither of these theories accounts for the absence of growth of crystals in castings, since there is presumably an amorphous cement between such crystals. In fact, most of the evidence in favour of the amorphous cement theory was obtained in experiments on cast metal.

Rosenhain has suggested that the crystals of a casting form under comparative liberty and are in equilibrium with each other, but his own experiments of pouring molten tin into water and finding no subsequent crystal growth on heating does not support this statement, as it can hardly be suggested that the crystals in this case formed in comparative liberty.

Both these theories, therefore, fail to account for the observations recorded in this research unless it can be shown that (1) either the crystals of a casting will grow, (2) or there is some fundamental difference between the boundaries of castings and those of worked and annealed metal. As already explained, all the evidence avail-

able is against the view that the crystals of castings can be made to grow on heating.

It is considered that all the evidence brought forward in this paper points to plastic deformation followed by heat as the true cause of crystal growth, and recrystallisation followed by crystal growth. The only exception to this is where an alteration of crystal form occurs when a metal passes through a phase change. The recrystallisation of electro-deposited metals frequently observed on heating, which may be thought to be an exception to the above generalisation, is really an instance of crystal change in a strained metal to which the slip-bands and twins present testify.

Apart from the direct evidence against any growth of crystals in castings, confirmatory evidence of the following nature has been obtained in this research: (1) Growth and recrystallisation can be induced by work; (2) the size of the crystals produced on heating at a given temperature after work is entirely dependent on the amount of deformation; (3) there is always in practice a limit to the crystal growth produced by work and heat in any metal, as a result of which a single crystal has not yet been produced by prolonged heating. Such a result, however, is theoretically imaginable, provided that the degree of deformation and subsequent temperature of heating could be adjusted to certain very precise conditions; (4) conclusions 8, 9, 10, and 11 above show that some cause of crystal growth must be looked for other than similarity of orientation, difference of crystal size, &c.

Whatever forms of energy operate during the growth or recrystallisation of a crystal on heating, the authors' conclusion is that the energy is imparted to the metal when it is deformed. That energy cannot be stored in the amorphous vitreous films which, according to Sir George Beilby, are the cause of work hardening in metals, because the growth of crystals in a worked metal proceeds after all mechanical softening has taken place. Hence all the amorphous metal must have recrystallised. It is, moreover, difficult to explain why the least deformation should produce the largest crystals on heating if growth depends on the presence of amorphous metal. The energy cannot be stored in the amorphous cement round the crystals, as conceived by Rosenhain, because: (1) All the available evidence is against the view that the crystals of castings grow; (2) The greater the surface area of a crystal the more energy it should possess, and on this view a large crystal should absorb a small one. It has been shown that this is by no means always the case.

No help towards an insight into the above phenomena has been derived from a study of the literature dealing with the structure of crystals. Crystallographers have confined themselves almost exclusively to measurement of geometrical form and the optical properties of crystals. The examination of crystal structure by X-rays in the hands of Professor Bragg and others has thrown some light on this subject. But this work is still in its infancy, and the knowledge that has been gained from it is not yet sufficient to explain the properties of crystals. Until, however, much fuller knowledge in this field has been won, it is considered that the true explanation of the effects of work upon metals, which includes both crystal growth and recrystallisation, will not be forthcoming.

The authors acknowledge with many thanks the assistance of Mr. H. M. Chapple in the mechanical tests referred to in the paper, and the kindness of Mr. Murray Morrison in furnishing them with specimens of aluminium of various degrees of purity for their experiments.

Submarine Signalling.—The observation that water will propagate acoustic waves is one of the many attributed to Leonardo da Vinci. In the early days of radiotelegraphy it was argued that it would be much simpler to develop submarine signalling which had been carried on with simple apparatus over distances of 100 km. The difficulty with underwater signals is that the range fluctuates very much. When the war again drew attention to the possibilities of submarine signals, the fluctuations of the range were partly ascribed to the microphone receivers. From an investigation conducted by H. Barkhausen and H. Lichte at the Laboratory of Torpedo Inspection at Kiel (*Annalen der Physik*, 62, pages 485 to 517, July 16 last) it would appear, however, that one factor has been overlooked in the propagation of acoustic waves through water, and that owing to this factor the improvement of the instruments in use is not very promising. The point is that the energy is not only distributed over larger areas, as one recedes from the source of the sound, whose intensity hence decreases with the square of the distance, but that there is also irregular absorption and dissipation of energy owing to convection currents in the water, and this dissipation becomes very important at large distances under certain conditions. In their experiments Barkhausen and Lichte made use of Fessenden oscillators and of the electromagnetic transmitters of the Signal-Gesellschaft, both the instruments being practically large telephones; their receivers were microphones. They found that change of depth in fairly deep water made little difference, but that damping in shallow water was always great, because the fluctuations of temperature and density (salt percentages) are strong in shallow water. In the Baltic the average range was 10 km. in summer and twice as large, 20 km., in winter; out in the open sea, near the coast the ranges were smaller, whilst occasionally very much larger ranges were observed in the deep water. This pronounced damping by convection currents, which also disturbs sound propagation through the air, is beyond control, and then the prospects of the system are not very good.

CATALOGUES.

Turbines.—Messrs. Brown, Boveri and Co., Baden, Switzerland, send a copy of their monthly journal "B-B-C-Mitteilungen," dealing chiefly with water turbines and generators and illustrating a large gear-cutting machine.

Electric Motors.—An extremely clear and simple explanation of the differences between squirrel cage and slip-ring motors and the various constructions of each, forms a useful preface to a catalogue of A.C. Motors, issued by the British Electric Plant Company, Limited, of Alloa and 66, Carrick-street, Glasgow. All the necessary dimensions, capacities, &c., are carefully tabulated for a considerable range of powers.

Electric Switchboards.—Some half-dozen switchboards mostly on a large scale, are illustrated and briefly described in a special catalogue issued by Messrs. Johnson and Phillips, Limited, Charlton, London, S.E. 7. The first, for example, supplied to the municipality of Sydney, N.S.W., is made up of independent and interchangeable units of totally enclosed all-steel cubicles with black enamelled slate fronts for use in a substation on a 5,000 volt three-phase 50 periods A.C. system, controlling five feeder and inter-connector circuits and three step down transformers. The six boards vary and all are examples of work done.

Refrigerating Machinery.—A catalogue of marine refrigerating machinery (CO_2) and another catalogue of stop valves, flanges, storage tanks, oil separators, purifiers and other parts for ammonia refrigerating machinery come from Messrs. Peter Brotherhood, Limited, Peterborough. These catalogues are very clear and explicit on the practical details of construction, materials, &c., which engineers require, and also contain a good deal of supplementary information which will be useful to those who have to operate the machines and provide estimates. A table is given showing the temperature required for the preservation of different commodities and the space occupied by these per ton.

Concentrator.—A table concentrator for separating two or more minerals of differing specific gravities is described in a catalogue received from Messrs. Fraser and Chalmers, Erith, Kent. The wet sand, or "pulp," from the grinding mills is evenly fed on the table, really a shallow trough with ribbed surface, and a slight reciprocating motion imparted to the table. In this process the tilting, length of stroke, distribution of washing water, &c., must be nicely adjusted, according to practical observation of the effects while the machine is working and the gear provides for these adjustments. The heavier particles move towards the end of the table where they are discharged while the lighter particles are washed off by the side.

Foundry Machinery.—The Incandescent Heat Company, Limited, Smethwick, Birmingham, send catalogues describing an annealing oven specially suitable for malleable castings, a charging fork and a shaking barrel. The oven, which is made in five sizes, for charges ranging from 4 tons to 20 tons, is fired with coal, which is converted into gas and burnt in that form, and the waste gases are used to pre-heat the incoming air required for combustion. The coal consumption is stated at about 10 cwt. per ton of castings, which is very considerably less than that of the beehive type of oven. The charging fork is a two-wheel truck with a low end platform and long frame on which an adjustable balance weight is carried. It is used for recharging the heated ovens with boxes of castings.

Forging Presses.—Repetition forgings were so largely imported from Germany before the war that our plant was quite unequal to the requirements of the fighting forces. This plant is not easily made, especially in large sizes, and it was felt that the nation should not in future depend on foreign supplies. Messrs. Davy Brothers, Limited, Sheffield, did a large share of the work of re-equipping the forge masters' plant and a new catalogue just received shows that they are following up the work by improving the controls, general construction and working speed of the presses. High speed in press forging is at once more economical and productive of better results—that is to say, the quality of the cooled metal is found by test to be better if the forging is done at high speed. This catalogue is a record of one of the most interesting of heavy engineering achievements.

Steam Turbines.—We have received from the British Electrical Engineering Company, Limited, Falcon Works, Loughborough, a copy of a supplement to their pamphlet on the Brush-Ljungström steam turbine. In this supplement they illustrate alternative arrangements of their 1,500-kw. and 3,000-kw. units, and also show the principal overall dimensions for four standard sizes ranging from 1,000 kw. up to 5,000 kw. on capacity. The extreme overall dimensions required for a 5,000-kw. plant, inclusive of turbine, generators, condenser and auxiliaries, is 36 ft. by 24 ft. 9 in. in plan by 21 ft. 6 in. in height. Of this height 14 ft. is below floor level, where the condenser is situated. The extraordinarily small space occupied by the turbine proper is shown in a section through a 1,500-kw. set. The pamphlet gives also the results of a trial made by Captain Sankey of one of these units. The test was carried out fifteen months after the unit had been put into service and without overhaul. With steam at 190 lb. per square inch (gauge pressure), and at a temperature of 634 deg. F. and with a vacuum of 28½ in. at the turbine exhaust, the consumption was under 12 lb. per kilowatt hour.

Semi-Portable Steam Engines.—The type of semi-portable engine now generally known as a "Locomobile" is an economical power plant for many situations where no degree of portability is required. The type is very well represented in those made by Messrs Marshall, Sons and Co., Limited, Gainsborough, who send a special catalogue describing and fully illustrating all parts and presenting an exceptionally fine illustration of the largest size, viz., 250 normal brake horse-power. This is a compound engine, with superheater, capable of developing up to 310 brake horse-power continuously and up to 350 brake horse-power for a momentary overload. The same type is made in eight sizes with condensers and eight sizes without condensers, the smallest being rated at 38 normal brake horse power. These engines occupy very little space, are easy to install, and the capital cost is less than of a plant with separate engines and boilers. The whole of the boiler tubing can be drawn out for cleaning and an interchangeable component may be kept ready for replacing the dirty one in exceptional cases where only a low quality of fuel water is obtainable and a lengthy stoppage for cleaning is undesirable. There are many situations in which this type of engine is more suitable than others. Either jet or surface condensers can be fitted, and mechanical stokers can be employed with the larger sizes. Special forms of furnaces are supplied for utilising bulky waste material as fuel.

Shipbuilding and Marine Engineering.—One of the best examples of trade literature we have seen for some time has recently come to hand in the form of a catalogue from Messrs. McKie and Baxter, Copland Works, Glasgow. This firm's productions, it will be remembered, include practically all types of marine steam engines and boilers, as well as sea-going cargo vessels, tugs, river steamers and small craft of all descriptions. In the catalogue marine engines are first dealt with, particulars being given of triple-expansion, compound and single-cylinder engines of the usual vertical type, as well as of diagonal engines for side-paddle steamers, and horizontal engines for stern-wheelers. Very complete tables of data, including outputs, weights and dimensions, are given for each type of engine, and these are followed by excellent half-tone illustrations of a few typical examples in each case. Marine boilers are similarly dealt with, the types listed including horizontal return-tube boilers, Admiralty pinnace-type boilers, locomotive boilers for marine work, and water-tube boilers. Notes on forced draught and liquid fuel are included in this section, and particulars are also given of propellers, steam reversing engines, circulating pumps and other auxiliary machinery. In the shipbuilding section tables of data and outline diagrams are given of cargo steamers, tugs, launches, side-paddle passenger steamers, stern-wheel steamers, and towing barges, and the section also includes a large number of reproductions of photographs showing the classes and types of vessels built or engined by the firm in recent years. Some of these vessels, it may be mentioned, were first fully erected in this country, marked for re-erection, and afterwards taken down and shipped abroad; others were supplied in the form of plates and angles, with forgings, working drawings and full instructions for construction in a foreign yard. A very useful feature of this section, and one which should prevent a considerable amount of unnecessary correspondence, is the inclusion of a series of diagrams which will enable clients to determine for themselves how different dimensions will affect the speed or carrying power of vessels. The diagrams are simple and self-explanatory, and no difficulty should be experienced in using them. In general it may be stated that the information given in the catalogue anticipates most of the questions likely to be raised by prospective customers, and this fact will doubtless be appreciated by foreign clients; at the same time the list is fully coded to facilitate telegraphic inquiries. The paper and printing are of excellent quality, and the book is bound in limp, padded covers of blue cloth, so that the firm must be congratulated on its production in every way.

Shipbuilding in the United States.—Although the United States Shipping Board received a considerable number of inquiries concerning vessels offered for sale, the formal opening of bids on September 1 found no proposals either for the steel or wooden ships offered by the Board, says *The Iron Age*, New York. Further efforts probably will be made to sell the ships, although there seems little present prospect that the Board will reduce its minimum prices. The Board has decided that it cannot sell chartered ships to the companies chartering them, even under sales contracts, without previous competitive bidding. As a result, it is likely that bids will be asked for some of the ships which have been operated under such charters. Plans have been approved by the Board for 10 tankers to be constructed under the law which provides special tax exemptions for American ships. These vessels are to be built for the Standard Transportation Company, a subsidiary of the Standard Oil Company. Five of the Standard Company's ships—four of 12,620 deadweight tons and one of 10,100 tons—are to be built at the Sparrow's Point plant of the Bethlehem Shipbuilding Company, and one of 10,100 tons at the latter's Union plant at San Francisco. Four of the 12,620-ton ships are to be constructed by the New York Shipbuilding Corporation, at Camden, N.J. Besides these, the Board approved the construction of a five-masted schooner by the Newcastle Shipbuilding Company for the Boston Maritime Corporation, Boston, and Richard Diebold of Newcastle, Me. According to the reports of the Bureau of Navigation, steel shipbuilding in the United States is still on the increase. On August 1, 1920, private American shipyards were building or under contract to build for private shipowners 389 steel vessels of 1,335,721 gross tons, compared with 334 vessels of 1,306,956 gross tons on July 1, 1920. These figures do not include Government shipbuilding or that contracted for by the Shipping Board.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

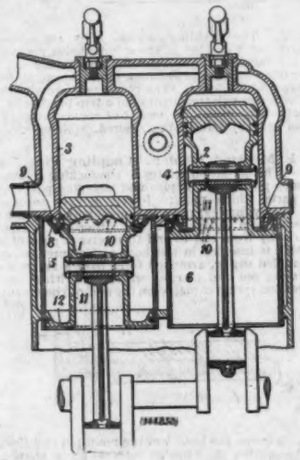
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

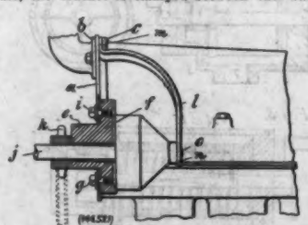
GAS ENGINES, PRODUCERS, HOLDERS, &c.

144,850. F. Sage and Co., Limited, London, and A. G. Forsyth, London. Lubrication of Internal-Combustion Engines. (1 *Fig.*) May 8, 1919.—The invention relates to internal-combustion engines of the two-stroke cycle type having cylinders of two diameters, the larger one constituting the compression cylinder and the smaller one constituting the power cylinder, an annular oil passage being provided around the outer end of the power cylinder, that is, the end adjacent to the compression cylinder, a suitable supply pipe or other conduit for the oil communicating with the said annular passage from the outside of the engine, and the said passage communicating with the interior of the power cylinder through a number of small radial or other ports or openings. According to the invention, the



annular oil passage is obtained by securing the projecting end of the power cylinder to a dished ring. The pistons are indicated by the numerals 1 and 2, their respective power cylinders by the numerals 3 and 4, and their respective compression cylinders by the numerals 5 and 6. The end of the power cylinder in each case projects into the compression cylinder, which latter is a separate casting secured in the crank-case. 9 is the annular oil passage which is obtained by securing outside the projecting end of the power cylinder a dished ring 8. A number of small radial holes 10 are made in the cylinder 3 to permit the lubricating oil supplied to the channel 9 to pass into the interior of the power cylinder. The power or compression extension 11 of the piston is dished, as shown at 12, to avoid fouling the projecting ends of the power cylinder and its oil ring. (*Accepted June 30, 1920.*)

144,521. S. S. Chenhall, South Brent. Distributor. (2 *Figs.*) September 8, 1919.—The invention relates to distributors employed in connection with the ignition systems of automobile engines, and consists briefly in providing a bracket on the engine casing providing a mounting for the distributor housing, which has eccentric means adapted to co-operate with the bracket when the housing is rotatably adjusted to tighten or slacken the means employed to drive the distributor shaft. *a* indicates an elongated metal plate forming a bracket for the, distributor housing and which may be formed at the side of the cylinder casing or applied as shown to existing engines. In the latter case, the bracket is clamped between the water outlet



pipe flange *b* and the cylinder head *c*, the bracket being bored out to a diameter equivalent to that of the outlet pipe, so as not to interfere with the flow of water. The outer end of the bracket *a* is bored out to form a bearing for an eccentric boss *e* on the distributor housing *f*, which is secured to the bracket by bolts *g* passed through holes in the housing *f* and partially circular slots formed in the bracket *a* concentric with the boss *e* on the housing, nuts *l* securing the bolts and the housing in adjusted positions. The distributor brush assembly is mounted on a shaft *j* passing through the eccentric boss *e* and carrying a sprocket pinion *k* to enable it to be driven from the camshaft of the engine. The eccentric boss *e* enables the distributor housing *f* to be adjusted rotatably to tighten the pitch wheel chain by which the distributor assembly is driven. As an additional support for the distributor, a spring clip *l* is employed, secured to the bracket *a* at *m*, and engaging with its free end *n*, which is of spherical or other suitable shape, a suitable recess in the end *o* of the distributor housing. (*Accepted June 23, 1920.*)

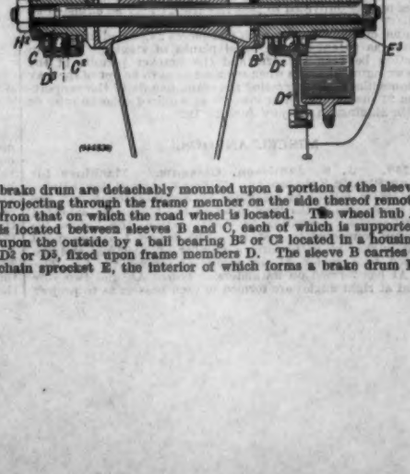
LIFTING AND HAULING APPLIANCES.

141,893. A. Butler, Watford. Cranes. (2 *Figs.*) April 9, 1919.—To adjust a load relatively to a rope or chain from which it is suspended, a suspension jack is employed, adapted to be suspended from a crane hook or rope and from which the load to be lifted is suspended in such a way that the load can be raised and lowered by hand relatively to the crane hook or rope with certainty and safety to enable the lashings to be adjusted and properly tightened prior to a load being raised, and to enable the final precise lowering of the load to its desired point of support to be also effected by hand. According to the invention, the suspension jack is constituted by a screwed spindle, the upper end of which has an eye for engagement by the crane hook or connection to the crane rope, and the lower end of which is furnished with a hand bar that slides in a hole formed therethrough and having knobs at the end whereby the spindle and crane hook and rope can be held against undesired rotation whilst manipulating the jack. The jack spindle *a*, which is of mild steel of hexagonal cross-section, is formed with a square thread near its lower end, which terminates in a boss *b*, pinned thereto and fitted with a hand bar *c*. Working on the screw-threaded part of the spindle *a* is a rotary nut *d*, the upper face of which is recessed centrally and fitted within the recess with ball races and balls *e* on which rests the lower end of a carrier mounted to slide on the spindle, and consisting of a cast metal sleeve *f* to the upper part of which are bolted at opposite sides of the sleeve two side plates *g* of steel, that project beyond the sleeve and form oppositely-extending webs between the free ends of which there

are bolted cast metal blocks *h* formed with grooves to constitute guides for rope lashings whereby an article may be secured to the jack ready for lifting. The bolts *i* that secure the blocks *h* to the carrier webs *g* have mounted upon them hooks *j*, which suspend freely from the bolts, between the webs *g*, the eyes of the hooks being located in recesses *k* formed in the cast metal guide blocks *h*. To prevent the carrier rotating relatively to the spindle, a plate *f1*, formed with a hexagonal hole which fits the spindle, is screwed on the top of the carrier casting *f*. A ring *l* in two parts and fixed to the upper face of the rotary nut *d* by screws, extends over a flange *n* formed on the lower end of the carrier sleeve *f*. The nut *d* has a pawl formed by the shaped end of a pin of circular cross-section, mounted to slide in a boss *q* radially extending from a ring *r* mounted to rotate on the nut *d*, between a flange *s* on the nut and the cover plate *l*. The pawl pin is provided with a shank *t* that extends through the boss *q*, and the outer end of which is furnished with a finger-piece *u*. A spring is located between a screwed plug *w* that closes the end of the boss *q* and the inner end of the pawl pin. The arrangement is such that by gripping the finger-piece *u*, and pulling the pawl out of engagement with the teeth *v* against the action of its spring, and then giving it a half complete turn before releasing it, the pawl can be set to rotate the nut in the desired direction for either right or left-hand operation of the pawl-carrying ring *r*. To facilitate operation of the said ring, it is provided with a boss *x*, into which is screwed an operating hand bar *y*. Connected to the top of the bar *a* is a shackle *z* whereby the apparatus can be suspended from a crane hook. (*Accepted May 5, 1920.*)

MOTOR ROAD VEHICLES.

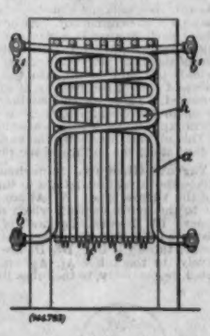
144,836. Coventry Premier, Limited, Coventry, and G. Funck, Coventry. Wheel Mounting. (5 *Figs.*) April 12, 1919.—The invention relates to driving wheels of motor cycles of the kind in which the hub is mounted upon a plain through bolt or axle which passes through a pair of sleeves, one at each side of the hub, each being mounted in a bearing carried by a housing on the frame. According to the invention, the gear wheel and



brake drum are detachably mounted upon a portion of the sleeve projecting through the frame member on the side thereof remote from that on which the road wheel is located. The wheel hub A is located between sleeves B and C, each of which is supported upon the outside by a ball bearing B^2 or C^2 located in a housing D^2 or D^3, fixed upon frame members D. The sleeve B carries a chain sprocket E, the interior of which forms a brake drum F, and this sleeve is formed with teeth or dogs at B^3 engaging similar teeth or dogs in the end of the wheel hub A. Between the other end of the hub and the sleeve C is the distance washer G. The hole in the washer is slightly larger than the diameter of the main part of the through bolt H, and from this hole extends radially a slot which is narrower than the hole but is slightly larger than the diameter of a reduced part H_2 at the end of the bolt. The bolt H extends through from one side to the other and forms a substantial support. It will be clear that the bolt H can be threaded partly into place, the washer G slipped into place over the reduced part and the bolt pushed fully home and the nut H^3 then tightened up. The washer cannot then fall out, and when the nut is tightened up the sleeves B and C are kept in full engagement with the hub. The through bolt revolves with the wheel and sleeves, and imparts stiffness to the construction. However, it takes the weight only and does not transmit any driving or braking stresses. The hub has no bearings of its own, and there are only two bearings B^2, C^2. The chain sprocket is located outside the frame member D and is separate from its driving sleeve B by being mounted upon serrations thereon at E^2, and retained by a nut E^3 screwing on the sleeve B. The ball-race housing D^2 is extended at D^4 to carry the brake blocks. (*Accepted June 30, 1920.*)

STEAM ENGINES, PRODUCERS, HOLDERS, &c.

144,783. D. V. D. Smith, Glasgow. Boilers. (3 *Figs.*) March 14, 1919.—The invention relates to boilers used for heating water or raising steam, in which the tubular sections are placed in opposite directions to one another and bent zig-zag-wise in an upward plane so as to form a horizontal flue or flues from front to rear of the boiler casing. The boiler consists of bent tubes *a*. These tubes *a* are bent and placed in series with each other, and so arranged that each lateral side tube has its inlet *b* near the base, and the outlet *b1* at the top of the boiler at the same side, while alternate tubes have the connections at



opposite sides of the boiler casing. The inlets and outlets are connected by short header-pieces bolted together. U-shaped tubes *f* are disposed so as to form the top, back and alternate fire-bars, and are similarly connected at the inlet and outlet of the tubes at the front of the boiler casing. The tube portions *f* forming part of the fire-gate are alternated by solid straight bars *e* of the usual pattern, these forming a strong base for the fuel without allowing the whole weight of the fire to be carried by the tubes *f*. The flues are obtained by the spaces *h* formed by the bent tubes *a* crossing each other. (*Accepted June 30, 1920.*)

144,473. North British Locomotive Company, Limited, Glasgow, and A. Anderson, Glasgow. Superheater Tubes. (8 *Figs.*) June 14, 1919.—The invention relates to return ends or headers of the type known as "torpedo ends" for superheater tubes of the kind by which two adjacent parallel tube ends are internally connected by a cap-like member into which they are fixed. According to the invention, the torpedo end is formed by a series of pressing and welding operations from a stamping of hollow conoidal form of circular cross-section—thus only requiring for its production dies of readily-machined circular section. These operations consist firstly in pressing the stamping in a die or to produce two diametrically opposed longitudinal grooves gradually increasing in depth towards the base end, of such contour that the base part assumes the form of two parallel circular sockets adapted to receive the tube ends while the opposite sides of the apex part are slightly flattened.

Fig. 1.

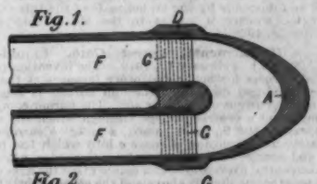


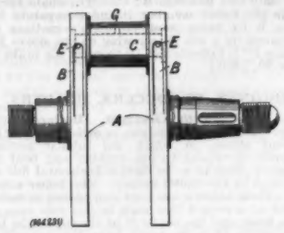
Fig. 2.

Fig. 3.

The tube ends are then inserted in the sockets, which are closed around them by pressure and heat. At the same time the central inwardly-projecting folds formed by the groove are forced into welding contact with one another. Finally the peripheries of the tubes are welded to the lips of the sockets. The stamping is thickened towards its apex A so as to give adequate allowance for wear at this point in the finished article. Towards the base is formed a cylindrical wall. The first pressing results in the formation of diametrically-opposed grooves C, a flattening of the apex part and the formation of two socket parts D towards the base, mandrels being inserted to ensure their proper formation, while the folds E of the grooves are brought closely adjacent to one another. After insertion of the tubes F, the socket parts D are closed upon them and the folds E of the grooves brought

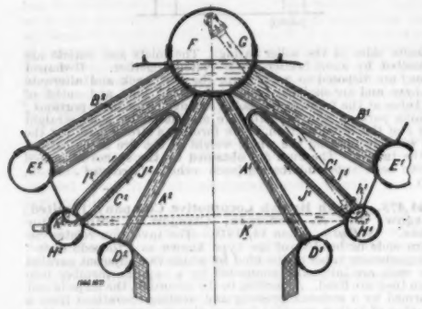
together, and finally the lips of the sockets are autogenously welded to the peripheries of the tubes, the ends of which have circumferential serrations G formed upon them to assist in securing them. (*Accepted June* 23, 1920.)

144,231. Powell Brothers, Limited, Wrexham, and E. A. Burney, Wrexham. Connecting Rods. (2 *Figs.*) February 24, 1920.—The invention relates to the lubrication of the connecting rods of engines. The crankpin is hollow and is adapted to contain oil which is fed to the surrounding big end bearing by one or more exit holes. According to the invention, the leading face of one or both crank webs is provided with a groove which communicates with the interior of the crankpin through a passage. In the leading face of each crank web A is formed a groove B, such grooves extending approximately as far as the axis of the crank pin C. The grooves B



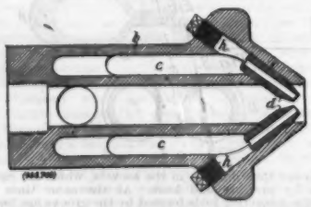
increase in depth towards the crankpin, and they start at or about points level with the axis of the crankshaft. At or near the point of maximum depth of each groove B a passage E is formed, radially to the crankpin, which puts the groove into communication with the interior of the crankpin. Centrifugal action, as the shaft rotates, thus aids the flow of oil into the crankpin by forcing in into the deepest part of the grooves, at which point the passages E are arranged. Thus, as the engine rotates, provided that there is oil in the crankcase, there is a continuous feed of oil into the crankpin under a pressure which varies with the engine speed. This oil then issues by the exit hole G from which grooves may lead along the surface of the pin. (*Sealed.*)

144,167. H. E. Yarrow, Glasgow. Superheater. (1 *Fig.*) September 30, 1919.—The invention relates to superheaters for water tube boilers of the Yarrow type. A^1, A^2 are nests of generating tubes nearest to the source of heat, which may be a coal fired grate or oil burner; B^1, B^2 are similar nests of tubes further from the source; between the two sets of generating tubes are placed the superheating tubes C^1, C^2; D^1, D^2 are water drums connected, respectively, to the tubes A_1, A_2, and E_1, E_2, are water drums connected, respectively, to the tubes B^1, B^2. Steam



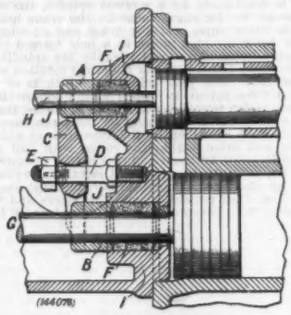
passes from the steam space of the drum F through a pipe G to a partitioned compartment A^1 of the superheater drum H^1, ascends by the branches I^1 of the tubes of the superheater C^1 and descends by the branches J^1 to the space in the drum H^1 surrounding the partitioned compartment A^1. In order that its temperature may be still further raised, the steam is then led by a pipe K to the partitioned space A^2 of the superheater drum H^2, ascends by the branches I^2 and descends by the branches J^2 of the tubes of the superheater C^2, whence it passes to the steam stop valve. (*Accepted June* 16, 1920.)

144,749. H. Clements, Forest Gate. Liquid-Fuel Burners. (3 *Figs.*) February 12, 1919.—The invention relates to liquid-fuel burners for boiler and other furnaces of the type wherein the liquid-fuel discharged through nozzles is atomised or sprayed by the current of steam or air. The burner comprises a casing containing a central passage through which the steam or air for spraying the liquid is passed, a jacket *b* surrounding the said passage and enclosing a space *c* into which the fuel is introduced and nozzles *d*, *d*, extending from the space *c* into the interior of the central passage in such a manner that the axes of the said nozzles pass the one slightly above and the other slightly below



the axis of the passage, whereby as jets of liquid fuel under pressure are ejected from the said nozzles they will come into contact with one another, and are thereby atomised, the spray produced having a conical form. Through the central passage a current of air or steam at considerable velocity is caused to flow around and between the nozzles, which current, on striking the fuel, further atomises the same and distributes it in the furnaces. At the rear end of the casing a lateral connection is provided, through which steam can be introduced into the central passage, and another for the introduction of the fuel to the jacket space *c*, the said connection being diametrically opposite to the steam connection so that the fuel, as it enters the jacket, comes into contact with the portion of the wall of the central passage against which the steam supply impinges as it enters the central passage, and which is thereby heated to a greater extent than the other parts of the said wall. The nozzles *d*, *d* are inserted through holes in the outer jacket wall *b*, which holes are closed by plugs *h*, *h*, and by removing these plugs the position of the nozzles can be accurately adjusted with relation to one another, and also readily cleaned. (*Accepted June* 23, 1920.)

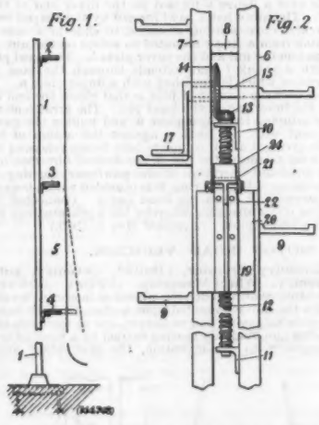
144,078. W. T. Bell, Lincoln, and F. J. Bretherton, Lincoln, Gland.—(2 *Figs.*) May 27, 1919.—According to the invention, where two or more glands A, B are used a dog or bar C is employed which engages a screw threaded stud D fixed to the cylinder cover I or some other part of the engine and is capable of rocking about same. The dog C has forked ends J, J for engaging squared ends of the glands A, B and has action on



the glands and also accommodates itself to the position of the glands A, B so that when acted upon by a screw nut E engaging the fixed stud D, the dog C will be moved and act upon all glands A, B at the one operation, the glands A, B acting upon the packing F in a proper manner irrespective of the position of the glands A, B. The glands are thus always forced down in line with the piston rod G, valve rod H or other rods. (*Accepted* June 16, 1920.)

SHIPS AND NAUTICAL APPLIANCES.

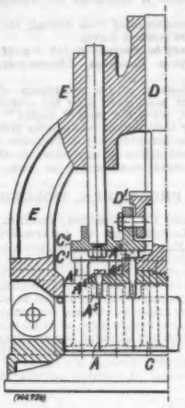
144,748. A. M. Allan, Glasgow. Staging Apparatus for Shipbuilding. (7 *Figs.*) February 12, 1919.—The invention relates to staging apparatus for use in shipbuilding, having a series of uprights carrying adjustable brackets and platform supports for supporting the platforms at any desired height or overhang. The staging apparatus consists of a series of uprights 1 carrying staging planks 2, 3 and 4, for supporting the workmen at work upon the side of the vessel 5. The upright consists of two channels 6, 7, connected together by staybolts 8 and by the cross-strips 9, which latter have projecting ends and project alternately to opposite sides of the uprights and serve as step-pieces by means of which the workmen may climb to the different stagings. Mounted upon the channel 6 are two brackets 10, 11, carrying a vertical screw 12 whose upper end has a bevel pinion 13 in mesh with a bevel wheel 14 on a cross-pin 15, mounted between the channels and having a square projecting end for the reception



of a crank handle 17, by means of which the screw may be rotated. Engaging the screw is a screw-threaded block to which is secured a plate 19 and a bracket-piece 20, which latter carries the supporting arm, the arm being connected to the bracket by a pin 22 passed through the holes in the side flanges of the arm and through one or other of a series of holes in the bracket 20. The bracket 20 may be extended to any desired extent and any required number of holes may be provided so that the arm 21 may be adjusted to suit the "tumble-in" or curve of the ship's side. The arm is of channel cross-section, and has end-pieces 24 turned up at right angles so as to engage the usual planks of staging. The pin connection between the arm and the bracket permits of the former swinging upwards when required so as to be out of the way when launching. By operating the crank handle 17 the supporting arm 21 may be raised or lowered as required so as to raise or lower the staging. (*Accepted June* 23, 1920.)

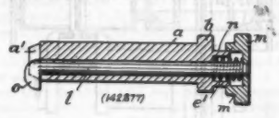
MISCELLANEOUS.

144,759. J. S. Jamieson, Glasgow. Machines for Dividing Plastic Substances. (5 *Figs.*) August 11, 1919.—The invention relates to machines for dividing dough and like plastic substances of the type in which the knives are arranged at right angles. According to the invention, the knives are detachably connected to a spider. The knives A are arranged at right angles, so as to form a number of divisions, and are connected to a spider A^1, by means of screws A^2, A^3. The spider A^1 has formed on its underside bosses A^5, and two slits arranged at right angles are formed in each boss so as to project down over the blades. The bosses, together with the edges of the blades, are tapped or screwed and connected to an extension A^4 on the spindle D, by means of the screws A^5. Each division is provided with a plunger C, and each row, or section, of plungers is fixed to a plate C^1, the latter being made in a piece with, and forming an integral part of, said plungers. The rows or sections of plungers are connected to a plate C^4, by screws so as to act



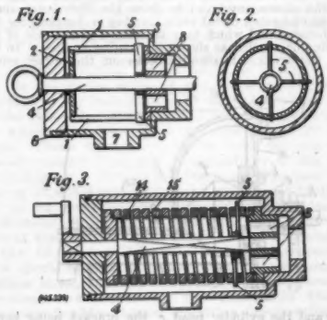
simultaneously. The dividing device A is connected to a spindle D, carried in a bracket E, the spindle being provided with mechanism for raising and lowering it, consisting of a rack formed on, or fixed to, the rod D, and a pinion engaging with said rack and operated by a lever. The plungers C are also operated by the spindle D, through the medium of a trip bracket D^1, which is automatically kept in gear by means of counterweights, but is thrown out of gear by hand when desired. (*Accepted June* 30, 1920.)

142,877. E. Mepsted, London. "Coupling Pins." (4 *Figs.* May 1, 1918.—The invention relates to the locking of removable joint pins, hinge pins, coupling pins and fastening pins employed to connect parts which require to be quickly separated or assembled. The cylindrical pin *a* is formed with a head *b* at one end and a transverse groove a^1 at the other end. The pin is bored eccentrically from end to end to receive a pin *l* of smaller diameter, which is inserted in the bore and secured at one end in a circular milled cap *m*, arranged to fit over a flange *n* on the head of the main pin and to co-operate therewith to enclose a helical compression spring e^1 placed on the end of the eccentrically



disposed pin *l*, between the head *b* of the main pin and the cap *m*. At its opposite end the pin *l* has an integral gib *o*, shaped to fit the transverse groove a^1 in the adjacent end of the main pin, in which it is normally held by the reaction of the compression spring e^1 at the other end. This gib *o* forms the locking member proper, the transverse groove a^1 in which it fits being so disposed across the end of the main pin and the radial dimension of the gib head being such that when set one way in the groove, it projects a sufficient distance radially to lock the main pin, as shown, and when turned through an angle of 180 deg. and set the opposite way in the groove it no longer projects from the main pin. (*Sealed*).

145,339. F. C. Fulcher, Grange-over-Sands. Filtering Apparatus. (14 *Figs.*) November 13, 1919.—The invention relates to improvements in filtering apparatus. According to the invention, a strainer for liquid comprises the combination with a straining wall, having a slot through which the liquid is strained, of a scraper comprising a blade projecting into said slot, and in permanent engagement therewith, the straining wall or the scraper being movable so that the blade will traverse the slot. A cylindrical straining wall has four longitudinal slots 1 at equal distances around its circumference. The cylindrical straining wall has end walls 2, 3, and is mounted loosely on a spindle 4,



on which is mounted a scraper having four blades, 5 projecting outwardly, one into each slot 1 and in permanent engagement therewith. The straining wall is enclosed in a housing 6 which has an inlet for the fluid to be strained 7. Outlets 8 for the fluid are provided in the end wall 3 of the cylindrical straining wall 1. Should the slots 1 become choked, the spindle 4 is withdrawn from the housing so that the blades 5 traverse the slots 1 and clear them. The straining wall may be a cylinder 14 having a spiral passage 15 constituting the slot through which the fluid is strained. The blades 5 are slidably mounted on the spindle 4. To clear the passage 15 the blades are revolved and consequently traverse the passage 15. (*Accepted July* 7, 1920.)